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CONTENTS

	Page
Scientific and Technical Services in the Fuel Industries	493
A Thirteenth Century Herbal. By Dr. T. A. Sprague	494
Ionic Membrane Equilibria and Distributions. By Prof. F. G. Donnan, C.B.E., F.R.S.	495
Unorthodox Views on Protein Structure. By Dr. D. Jordan Lloyd	496
Co-operative Research in the Electrical Industry of Great Britain. By E. B. Wedmore, C.B.E.	498
Influence of Carbamic Esters (Urethanes) on Experimental Animal Tumours. By Dr. Alexander Haddow and Dr. W. A. Sexton	500
Origin of the First European Potatoes and their Reaction to Length of Day. By Dr. J. E. van der Plank	503
Obituaries :	
Prof. A. E. Dixon. By Prof. Joseph Reilly	505
Dr. J. D. Rolleston. By Dr. E. Ashworth Underwood	506
News and Views	507
Letters to the Editors :	
Chemical Taxonomy.—Prof. H. Munro Fox, F.R.S.	511
An Antibiotic from *Spiraea aruncus* L.—Dr. E. P. Abraham, Dr. N. G. Heatley, R. Rolt and E. M. Osborn	511
A Light-Sensitive Enzyme in Cow's Milk.—Prof. H. D. Kay, O.B.E., F.R.S.	511
Pyruvic Acid in the Juice of Onion (*Allium Cepa*).—E. J. Morgan	512
Inhibitory Effects of the Corpora Cardiaca and of the Corpus Allatum in *Drosophila*.—Dr. Marguerite Vogt	512
Lack of Optomotor Reactions in a White-eyed Mutant of *Culex molestus*.—Dr. H. Kalmus	512
Sweat Glands.—Mary Dempsey	513
Reaction of Nucleic Acid to Aceto-carmine.—J. Chu	513
Abnormal Precipitation of Proteins from Antitoxic Horse Plasma in the Presence of Phenolic Compounds.—A. J. Harms	514
Digitalis and Voluntary Muscle.—Dr. G. B. West	514
Parasitism of *Striga* sp. on *Dolichos Lablab* Linn.—F. W. Andrews	515
Planck's Radiation Formula Derived without Atomicity.—Prof. Herbert Dingle	515
Geodesic Form of Schwarzschild's External Solution.—Prof. V. V. Narlikar and K. R. Karmarkar	515
A Simple Proof of the Lorentz Transformation.—M. D. H. Strauss	516
A Generalization of Special Relativity Theory.—Dr. H. C. Corben	516
Postulates of Probability.—Prof. R. T. Cox	517
Large Dispersion in X-ray Spectrography Obtained by Using Ground Faces.—G. Aminoff	517
Accuracy of Atomic Co-ordinates Derived from X-ray Data.—A. D. Booth	517
Crystal Structure of Sodium Nitroprusside.—P. W. Cooke	518
Decomposition of Martensitic Steel Above and Below 300° C.—R. D. Heidenreich, L. Sturkey and H. L. Woods	518
Molecular Weight and Polydispersity of Rubber by Diffusion Measurements.—Dr. A. G. Passynsky and T. V. Gatovskaja	518
Mechanism of the Beckmann Rearrangement.—Dr. Brynmor Jones	519
Activation of Catalysts in Olefin Reactions.—Dr. W. J. Hickinbottom ; Prof. M. Polanyi, F.R.S.	520
A Dropping Mercury Electrode of Improved Sensitivity.—J. P. R. Riches	520
Research Items	521
Breeding Methods in Livestock Improvement. By Dr. J. E. Nichols	523
National Academy of Peiping and its War-time Activities	524
Recent Work of the Physico-Mathematical Institutes of the Academy of Sciences of the U.S.S.R.	525
The Eniac, an Electronic Calculating Machine. By Prof. D. R. Hartree, F.R.S.	527

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SCIENTIFIC AND TECHNICAL SERVICES IN THE FUEL INDUSTRIES

THERE is a practice of fuel technology of long standing, if empirical, which in the past generation has been developed scientifically with varying intensity in almost all industrialized countries. There is a technical literature on fuel circulating throughout the world, and there are substantially no secrets on the subject. This means that, although improvements should be sought, few revolutionary discoveries can be expected. For example, in the past twenty years, large modern steam generators have been available to produce steam from coal with a thermal efficiency approaching 90 per cent. There is here little room for increase in thermal efficiency. In the carbonization of coal, the position is analogous. The design of modern gas retorts and coke ovens permits the carbonization of coal with an efficiency of 80 per cent. Although present practice lags behind this standard, the scope for discovering increased efficiency is not great. The real scope for advance lies in the direction of complete gasification ; but the gas industry started on this quest fifteen years ago, and by now has gone some way towards the operation of large-scale plant. The efficiency of gas producer plants has long ago attained similar high thermal efficiency.

It may be inferred from the above that there is little scope for any revolutionary increase in the thermal efficiency of the art of processing fuel. On the other hand, there are many fields of utilization where normal practice falls short of the standard of efficiency which at best is already attainable. In these, the solution requires only the application of existing knowledge, as is exemplified by the war-time work of the Ministry of Fuel and Power through its engineering staff—both permanent and voluntary—and publications. In association with this is the need for new plant and apparatus likely to promote more efficient utilization. Change in household practice will call for great efforts in this direction.

The Association of Scientific Workers has recently prepared an "Interim Memorandum for the Scientific and Technical Services for the Fuel and Power Industries", which is stated to be based on the experience of students of the natural and social sciences who have been concerned with fuel and power problems, or in war-time work of the Supply and Service Ministries where scientific methods have been applied on an unparalleled scale. It makes recommendations, the keystone of which is the establishment of a single unified scientific and technical service, to meet the whole requirements of the nationalized fuel and power industries of Britain. It is proposed that the co-ordination, stimulation and regulation of all research activities should be the responsibility of the Ministry of Fuel and Power, through a controller of research and development. For the central research establishment, a programme is suggested which includes : (*a*) survey of coal resources ; (*b*) coal mining ; (*c*) domestic fuel production and utilization ; (*d*) indus-

trial use of coal, including steam generation; (e) conversion of coal into products of high value with the object of (i) working the coal seams to best advantage, (ii) increasing the efficiency of utilization, and (iii) creating new industries using coal as a raw material for products of high value for export.

To these proposals an emphasis is given comparing them with that which drove the development of radar during the War. It is, however, open to doubt whether the analogy between radar and fuel technology is a close one. Brilliant though the achievement of radar no doubt was, its development faced another sort of difficulty. It involved the application of a branch of new physics by a relatively small body of scientific workers essentially of one mind and undisturbed by economic factors or personal prejudices.

It is easy to condemn industries for inefficiency or waste; but systems of production, marketing and utilization have not been conducive to thrift. In some industries, the cost of fuel plays only a minor part in the cost of production; and the incentive to spend money on plant or control has been insufficient to prove effective. War-time experience has disclosed this in some of the largest concerns. Indeed, growing scarcity has probably produced more effect than all exhortations—both spoken and written. Reducing consumption is a sure method of resisting short supply. Unfortunately, short supply of coal, due to low output, is something on which scientific effort makes little immediate impression. There are human problems which still await solution, and current events only emphasize this.

In all endeavours to raise the efficiency of fuel utilization, education can play a part which is recognized in the memorandum. It urges the establishment of a college of fuel technology. It is apparently overlooked that at least half a dozen places of university rank in Britain are engaged on teaching and research on various aspects of fuel technology. Moreover, there are other technical organisations and institutions making their contributions. Surely it is advantageous to develop studies and investigations on fuel in the closest contact with the area where coal production and utilization are practised. War experience has revealed the need for education, not only of higher technicians, but also of skilled plant operatives trained to understand combustion processes. Existing public education authorities usually meet the demand for this when it arises, but the demand is less active than it should be.

Mention is made in the memorandum of the research and development contracts which have been freely used during the War. By these, the State has supported financially branches of industrial research even on quite a small scale, sometimes with firms or individuals, and with important useful results. This may prove advantageous in peace-time, if it is certain that action taken will promote rather than hinder the efforts of the individual.

In conclusion, it may be said that the memorandum is an interesting document enumerating the range of problems in connexion with British fuels and the agencies for their investigation and control. It advocates that the whole should be committed to a single organisation. If the major industries of a country are to be nationalized, the State can scarcely escape taking an interest in all that concerns fuel technology. Moreover, there must be problems and industrial enterprises so great as to require nothing less than the action and support of the State. There runs through the memorandum, however, a strong advocacy for complete centralization of all activities. It seems to imply that given a sufficiently large and complex organisation, all difficulties could be solved. This will not find general acceptance among those directly concerned with the production and use of fuel, and present experience does not support the view.

A THIRTEENTH CENTURY HERBAL

The Herbal of Rufinus

Edited from the Unique Manuscript by Lynn Thorndike, assisted by Francis S. Benjamin, Jr. Pp. xliii+476. (Chicago: University of Chicago Press; London: Cambridge University Press, 1945.) n.p.

THE botany of the Middle Ages has commonly been held in low esteem by historians of science, who have regarded it merely as a phase in the decline of the text of Dioscorides. The publication of Dr. Lynn Thorndike's edition of Rufinus affords striking evidence, however, that in thirteenth century Italy, at all events, there was a growing interest in plants themselves as well as in their medicinal properties. Rufinus, whose herbal was composed not long after A.D. 1287, was a monk, titular abbot of the monastery of Tyre, and penitentiary to the archbishop of Genoa. His original manuscript is unknown; but the first half of the unique manuscript now reproduced may date from the late thirteenth century, while the second half seems to be written in a later, Bolognese hand. The table of contents seems to have been added still later.

There is an indication that the treatise of Rufinus was originally illustrated with figures of herbs: describing 'gariofilata', he says that it has six small leaves under a large one which are almost hidden by it, "as you see here" (fol. 57 vb). The herbal was mainly a compilation from Dioscorides, "Circa Instans", Macer, "Alexander Philosophus", "Magistri Salerni", Isaac Judæus and the "Synonyma" attributed to Nicolaus Salernitanus, but contained much original matter, including descriptions of plants as well as remarks on their properties and application. Rufinus, indeed, described numerous plants, such as 'herba Roberti' and 'herba Gualterii', the virtues of which were unknown to him. The citations from Dioscorides were apparently taken from a text which may be no longer extant. Those from "Alexander Philosophus" correspond to matter in the "Antidotarium Nicolai".

One fact which emerges from a study of the herbal is the extraordinarily limited circulation obtained by even important manuscript works in the Middle Ages. Rufinus apparently did not know of Albertus Magnus' celebrated treatise "De vegetabilibus et plantis", although it had been composed long before the death of Albertus in A.D. 1280. The two authors did not even use the same sources: Albertus adhered to the Parisian, Aristotelian and scholastic tradition, whereas Rufinus followed the medical tradition of

Salerno and Italy generally. Manuscripts were costly, and few students could afford the money to buy, or the time to copy, those outside their own special field of interest. The work of Rufinus largely dropped out of sight, but is frequently cited in the early fifteenth century manuscript herbal of Benedetto Rinio, which is sumptuously illustrated by the Venetian painter, Andrea Amadio. Rinio's herbal was consulted towards the close of the fifteenth century by Pandolfo Colenuccio in a spice-dealer's shop at Venice, where it is now preserved in the library of St. Mark's.

The plants and drugs cited by Rufinus' authorities were largely oriental, whereas many of those described by him were natives of Liguria, known to and used by the local herbalists. Rufinus appears to have correctly identified many of the drugs mentioned by Dioscorides; for example, 'eupatorium' (*Agrimonia Eupatoria*), for which he adopted the medieval name 'agrimonia', retaining the name 'eupatorium' for a kind of wild sage. This contrasts with the practice of sixteenth century herbalists, such as Fuchs, who scrupulously retained the Dioscoridean nomenclature.

Although much time and scholarship has been devoted to the deciphering and editing of classical and medieval herbals, comparatively little progress has been made in the identification of the plants concerned. Systematic botanists are largely occupied in the writing of 'floras' and the preparation of monographs of particular groups, and are unfortunately apt to regard the study of medieval botany as outside their province and indeed as almost beneath their dignity. The herbal of Rufinus, however, offers a promising field of investigation by a botanist with a good knowledge of the Italian flora and of that of the Near East. Some of the plants can be identified immediately on reading their descriptions: 'centaurea maior' of Rufinus, for example, is undoubtedly *Blackstonia perfoliata*, and 'guinzerna' (*'vihalba'*) was evidently a clematis. In other cases the interpretation of descriptions is more difficult, owing to the peculiar terminology employed by Rufinus, so that the botanist has a twofold task, to identify the plants concerned, and, *pari passu*, to prepare a glossary of the technical terms used in their description. Until this double task has been performed for all the medieval herbals, our knowledge of the botany of that period will remain very fragmentary.

T. A. Sprague.

IONIC MEMBRANE EQUILIBRIA AND DISTRIBUTIONS

The Donnan Membrane Equilibrium

By Dr. S. G. Chaudhury. Pp. viii + 112 + xv. (Howrah: A. P. Bhattacharya, 1945.) 10 rupees.

THE famous theorem of Gibbs concerning the equality of the chemical potential μ of an independent component throughout a system of co-existent phases in equilibrium at constant temperature and pressure is widely known. It is perhaps not so well known that, if external fields of force or electrically charged components (ions or electrons, for example) are present, an extension of the foregoing theorem is required, though Gibbs himself dealt with this matter in the case of a gravitational field. The subject was very well discussed in an important paper by Milne[1] in 1925. If the system of phases be under the action of an external field of potential Ω per unit of mass, then, corresponding to each independent component, an equation of the type $\mu + \Omega =$ constant holds throughout the system. This corresponds to Gibbs' result for a gravitational field. A similar state of affairs holds good for a centrifugal field. A very interesting type of this sort was dealt with on Gibbsian lines by Kai O. Pedersen[2] in 1934. Let us now suppose that certain components have associated with them electric charges of amount e_i per unit mass (where the subscript refers to such a component i). The presence of the charges will give rise to an electrostatic field, and there may be also present an external electrostatic field. Denote the total electrostatic potential by Ψ. Then, instead of the condition $\mu_i =$ constant, throughout the system of phases, we have the condition $\mu_i + e_i\Psi =$ constant, and if a gravitational field of potential Ω per unit of mass is also present, the condition becomes $\mu_i + \Omega + e_i\Psi =$ constant. If we are dealing with the distribution of ions in ordinary laboratory apparatus (say in experiments on membrane equilibria of ions across a semi-permeable membrane) the term Ω practically cancels out. Not so, however, the electrical term $e_i\Psi$, which may now be written in the form $z_iF\Psi$, where z_i is the electrovalency of the ionic component i (positive for a cation and negative for an anion) and F is the Faraday constant. Both μ_i and the term $z_iF\Psi$ refer now to a gram molecule of the ion i. The expression $\mu_i + z_iF\Psi$ has been called the 'electrochemical potential' by Guggenheim[3], to whom we are indebted for its introduction and practical use in modern physical chemistry.

With the aid of the electrochemical potential and the methods of Gibbs, the theory of membrane equilibria has been worked out in a rigorous and comprehensive manner[4]. Recently, Dr. S. G. Chaudhury, of the University of Calcutta, has produced the book referred to at the head of this notice dealing with membrane equilibria and other ionic distributions. As the author puts forward his own 'theory', in sharp contrast with the existing thermodynamic one, the matter calls for some comment. In order to be as brief as possible, we shall consider only the author's equation 20 on page 6 of his book, and give its simple deduction from existing thermodynamic theory.

The case considered is one of ionic membrane equilibrium between two solutions (in the same solvent) separated by a semi-permeable membrane, and the equilibrium distribution between the two solutions of the freely diffusible ions of an electrolyte which gives per molecule on ionization one cation and one anion. The two solutions will be indicated by single and double accents. Now, if the solutions be treated as ideal and are so dilute that the mol fractions of the solvent in each may be, with sensible accuracy, equated to unity, it is known[5] that for the distribution of an ion i we may write

$$E = \Psi' - \Psi'' = \frac{RT}{z_iF} \log \frac{N_i''}{N_i'},$$

where Ψ denotes the electrical potential of a solution (the same for all the ions), z_i the electrovalency of i (*positive* for cations and *negative* for anions), and N_i' and N_i'' mol fractions of i. Transforming, we get $N_i'' = N_i'e^x$, where $x = \dfrac{z_iEF}{RT}$. If now we employ, instead of the signed quantity z_i, the common

(unsigned) chemical valency z, and if the solutions are so dilute that we may equate a ratio of mol fractions to a ratio of molal concentrations, we obtain $c_+'' = c_+' e^x$ and $c_-'' = c_-' e^{-x}$, where now $x = \frac{zEF}{RT}$, and the suffixes + and − indicate cations and anions respectively. Let us now suppose that the solution (′) contains the same concentration c' of both cations and anions of the electrolyte considered, but that this is not true for the solution(″) which contains the indiffusible ion or ions; then it follows that

$$c_+'' + c_-'' = c'(e^x + e^{-x}) = 2c' \cosh x.$$

Denoting now by $c_\pm$ arithmetical mean concentrations of the ions of the electrolyte considered, that is,

$$c_\pm'' = \tfrac{1}{2}(c_+'' + c_-'') \text{ and } c_\pm' = \tfrac{1}{2}(c_+' + c_-') = c'$$

we get finally the equation

$$c_\pm'' = c' \cosh x = c_\pm' \cosh x,$$

which is identical with Dr. Chaudhury's equation. It is clear, therefore, that his equation is a very obvious and elementary deduction from existing thermodynamic theory and presents no novelty. Moreover, his employment of the Maxwell–Boltzmann distribution theorem offers nothing new, for the thermodynamic equations given above, such as, for example, $N_i'' = N_i' e^x$, are just examples of this theorem as applied to the special case considered. Dr. Chaudhury assumes the solution (″), which contains the colloid or non-diffusible ion (ions), to consist of "a charged material and a double layer which extends up to the membrane through which the colloidal particles or non-diffusible ions cannot pass". Such an assumption is both unnecessary and unjustifiable; but is apparently made in order to align the membrane equilibrium cases with the author's treatment of cases where (in the absence of a membrane) ions are distributed in various ways.

There is not space available to go into the consideration and criticism of other sections of the book, but enough has been said to show that, at least in the case of ionic membrane equilibria, there exists no new 'Chaudhury theory'. Nor do the equations of ionic membrane equilibria form a 'special' case of this soi-disant theory.

F. G. Donnan.

[1] *Proc. Camb. Phil. Soc.*, **22**, Pt. 4, 493 (1925).
[2] *Z. phys. Chemie*, **170**, A, 41 (1934).
[3] *J. Phys. Chem.*, **33**, 842 (1929).
[4] Donnan, F. G., and Guggenheim, E. A., *Z. phys. Chem.*, **162**, A, 346 (1932); Donnan, F. G., *Z. phys. Chem.*, **168**, A, 369 (1934).
[5] See equation 27 of the second paper mentioned in ref. 4.

UNORTHODOX VIEWS ON PROTEIN STRUCTURE

On the Structure of the Protein Molecule

A Chemical Investigation. By N. Troensegaard. Second edition. Pp. 126. (Copenhagen: Einar Munksgaard; London: Oxford University Press, 1944.) 14 Danish crowns.

UNORTHODOXY in science should always be welcomed and given a hearing: how else would the theory of phlogiston have been relegated to limbo? Unorthodoxy, however, must be sure that its own eye is clear of beams while it is decrying the motes in the eyes of the orthodox. Troensegaard's researches in protein chemistry have now been going on for about twenty-five years. He points out, quite correctly, that to boil a protein for many hours in a fierce reagent like 20 per cent hydrochloric acid may be to destroy the very structures which the chemist is seeking. His alternative line of attack appears, however, to be even more violent. To start with, his proteins are thoroughly dried, even to the extent of storing over phosphorus pentoxide. Proteins exist naturally in aqueous surroundings, and when they are isolated from these, some 'bound water' goes with them, and only under very limited experimental conditions can it be removed without turning the native protein into something else. Troensegaard finds that if dry gelatin is dissolved in anhydrous methanol-potassium hydroxide and neutralized with ethyl acetate, the total amount will be precipitated if more dry methanol is added. He argues, therefore, that the gelatin has formed a colloidal solution; hence there cannot have been any great splitting up of the molecule. True, but there can have been other changes, such as ring closure following the removal of bound water from active centres in the gelatin molecule.

Troensegaard claims that all proteins have approximately the same elementary composition ($C_{19}H_{14}N_{2\cdot7}O_{2\cdot2}$) and that the polypeptide theory cannot explain this. Proteins, however, are not all alike in their nitrogen/carbon ratio, a notable example being the protamines. The recent complete analysis of β-lactoglobulin in terms of amino-acid units is also strong evidence in favour of the polypeptide theory. However, unorthodox though it may appear to most protein chemists to handle proteins in a non-aqueous system, Troensegaard's experimental findings must be taken seriously by all students of protein structure. His method is straightforward. He dissolves a dry protein in a non-aqueous solvent (a certain amount of choice exists here, the selected solvent varying with the protein, but anhydrous methanol-potassium hydroxide dissolves most proteins, and after neutralization with ethyl acetate the alkali protein is soluble in glacial acetic acid), acetylation with acetic anhydride follows, the acetylated protein is dissolved in chloroform and precipitated in dry ether. Hydrogenation with sodium in dry amyl alcohol is the next stage, and a short cold hydrolysis, after which the addition of ether separates the products into ether-amyl alcohol-soluble bases (*B* and *C* bases), a water-soluble fraction (*D* bases), and ammonia. The *B* and *C* bases are pyrroles and piperidines. The only aliphatic amine identified is isoamyl amine, which forms only 1–2 per cent of the protein. α-Methyl pyrrolidine has been isolated from a few proteins. The *D* bases from several proteins have the same acid-binding capacity for hydrochloric acid and for chloroplatinic acid reckoned in terms of equivalents of acid bound per two atoms of nitrogen. In many cases the elementary composition of the *D* bases from different proteins is the same.

Troensegaard argues that pyrrole and piperidine rings must form sub-units in the protein molecule. Certainly the theory of protein structure must account for their occurrence as end-products after his experimental treatment. Are they pre-formed in the protein molecule, as he believes, or is the pattern of the molecule such that they are formed by the bonding of spatially adjacent groups during his method of analysis? Most protein chemists will consider the latter hypothesis the more probable.

D. Jordan Lloyd.

The Spell of the Honey Bee

By W. Eric Kelsey. Pp. viii+264+49 plates. (London: Chapman and Hall, Ltd., 1945.) 15*s.* net.

THIS work stands out above the usual level of beekeeping guide-books. It is written in a pleasant style, beautifully and copiously illustrated, provided with many working drawings of appliances (fully dimensioned), and almost free from errors in its references to mathematics and physics—a pleasant change from some we have read. The order adopted is a good one—the history of a colony throughout the year, with diversions to practical beekeeping as occasion suggests. This is followed by a section on hives and appliances, and their making, the practical management of an apiary, the handling of bee produce, and information on pests and diseases. The book concludes with chapters on pollination, bee anatomy and 'mental processes'.

There are some matters that could be improved. The author has put too much trust in Cheshire—sixty years out of date—and that author's disciples. The chapter on diseases requires thorough revision. The cells of the comb are scarcely ever of the ideal geometrical forms suggested, being the result of the action of statical forces on plastic wax. There is confusion in the account of the sugars occurring in honey. If these and a few other matters are set right, the book would become the best practical guide-book for British beekeepers. It is certainly the best-illustrated, and the artists—they deserve that appellation—who produced the 146 figures in the text and plates are most heartily to be congratulated. They are: Messrs. Douglas Dingle and H. W. Howard, the Rev. G. H. Hewison, Mr. P. S. Milne (of Rothamsted) and the author himself (responsible for the line drawings). The eminently readable style adds to the attractiveness of a fine piece of work.

A. D. B.

The Physical Structure of Alloys

An Introduction to Modern Physico-Chemical Theories. By C. E. Beynon. Pp. 126. (London: Edward Arnold and Co., 1945.) 6*s.* 6*d.* net.

THIS book, of less than 120 pages, is designed to interest the industrial and student metallurgist in a province of science which is on the boundary of physics and chemistry. Within its pages is a brief survey of the present state of our knowledge of the structure of matter, with special reference to metals and alloys. The book starts at the beginning of things—the electron—and goes on to describe the structure of the atom and the ordering of atomic species in the Periodic Table. The next step in the architecture of solids is the structure of molecules and crystals and the relation of metallic to other types of crystals. The results of X-ray analysis are clearly presented with a number of good illustrations, and the growth of ideas about the nature of solid solutions and intermetallic compounds is set out in an easily understandable form. The book concludes with a chapter on the physical theory of metals and a bibliography for further reading.

In so small a space the author could not hope to deal adequately with any particular phase of his subject, but the book can be confidently recommended to all who are interested in metals and alloys and who wish to know more about them. The specialist will not need it, but as a guide to a student for a course of reading or to a teacher for a course of lectures, it should prove valuable.

How to Study Birds

By Dr. Stuart Smith. Pp. 192+12 plates. (London: Wm. Collins, Sons and Co., Ltd., 1945.) 8*s.* 6*d.* net.

Birds of the Sea

By R. M. Lockley. (King Penguin Books.) Pp. 32+24 plates. (Harmondsworth and New York: Penguin Books, Ltd., 1945.) 2*s.* net.

The Swallow

By Eric Hosking and Cyril Newberry. Pp. 60+28 plates. (London: Wm. Collins, Sons and Co., Ltd., 1946.) 7*s.* 6*d.* net.

THE circle of non-specialists who are becoming interested in birds and their behaviour is increasing at a fairly rapid pace. These three books will, therefore, find a ready-made market, and each of them is worth purchasing on merit. Dr. Smith's book, despite some minor defects, is undoubtedly the best book yet written to guide the layman in pursuit of a new hobby. Besides anticipating the kind of questions which the beginner would be likely to ask, Smith also provides those kinds of practical hints, drawn from his own experience, which would be invaluable to a beginner. Lockley's book is as good as anything which has been published in this admirable series, while "The Swallow" is a simple account which could easily be followed by the most elementary student. The photographs and illustrations in all three books are generally excellent.

The British Pharmaceutical Codex, 1934. Supplements 1–7

Pp. 408. (London: Pharmaceutical Press, 1946.) 21*s.*

THE last edition of the British Pharmaceutical Codex appeared in 1934. This most valuable book provides an indispensable extension of the brief official monographs of the British Pharmacopœia. It has been kept up to date by the publication of seven supplements during the years 1940–45, and these have now been published together in one volume, which is much easier to handle than seven thin booklets. The first supplement deals with standard dressings and the fifth with quinine preparations. The other supplements contain a large number of new monographs and amendments to old monographs. The list of proprietary names has been considerably extended. A complete index covering all these supplements is included, and this makes it easy to find any information about specific preparations; but it is hoped that it will not now be long before this rather cumbrous accumulation of supplements will be replaced by a new edition of the Codex.

Textbook of Botany

By J. M. Lowson. Ninth edition, revised and largely rewritten by Dr. W. O. Howarth and Dr. L. G. G. Warne. Pp. viii+584+8 plates. (London: University Tutorial Press, Ltd., 1945.) 12*s.* 6*d.*

THE appearance of Lowson's well-known "Textbook of Botany" in its ninth edition is a tribute to the soundness of the principles on which the book was originally based. Now Dr. W. O. Howarth and Dr. L. G. G. Warne have revised and very largely re-written the entire work to make it more than adequate for the needs of most students taking present-day intermediate examinations. The chapters have been planned both to supplement oral tuition and to reinforce the student's practical work. Most of the original drawings have been re-drawn by Miss M. W. Jepson and make the book of even greater value than the earlier editions.

CO-OPERATIVE RESEARCH IN THE ELECTRICAL INDUSTRY OF GREAT BRITAIN

By E. B. WEDMORE, C.B.E.

BOTH the manufacturing and the electricity supply sides of the electrical industry in Britain were highly organised and practising co-operation long before the incorporation of the British Electrical and Allied Industries Research Association. The Institution of Electrical Engineers began co-operative research in 1913. The manufacturers started shortly afterwards. These activities were merged in the 'Electrical Research Committee' in 1917, which adopted the organisation of a research association in 1920 and thus has just passed its jubilee.

The Electrical Research Association is, however, peculiar in that it has never been the principal organ of research in the industry, which covers a very wide field of diverse activities; the larger manufacturers in the several sections possessed specialized laboratories prior to its formation. To-day, 90 per cent of the research work done by the industry is carried out in such laboratories. On the other hand, the electricity supply section has limited facilities for research outside the Association; only a few of the larger undertakings, such as the Central Electricity Board, have any such facilities. The technical problems of that section are, nearly all, common to the whole section and appropriate for treatment by the Electrical Research Association.

The electricity supply industry in Britain is still the largest user of electrical plant and apparatus, but the manufacturers are in turn large users of other manufacturers' products, and it is this user interest that most readily lends itself to co-operative research. Prior to the formation of the Electrical Research Association, there was practically no research conducted in the user interest save where a user conducted his own research; this led to overlapping and some confusion. Immediately, however, such work was put on a co-operative basis, manufacturers were able not only to share the cost but also to obtain great benefit from closer technical co-operation both with their customers and with their competitors in problems of common interest. Indeed, to-day it is well known that the solution of some of these problems, so secured, has given a return showing gains greatly exceeding the Association's total expenditure from its inception to the present day. Incidentally, the larger part of these gains has been passed on to the public, who are able to obtain a cheaper and more reliable supply of electrical energy and many novel electrical appliances.

The efficiency of steam plant can be greatly improved by raising working temperatures; but to realize this involves steels for boiler construction and turbines, etc., able to withstand high working stresses for many years although red hot, also an accurate knowledge of the properties of steam at those temperatures. The electrical industry stood to gain so much from any such advance that, possessing the necessary co-operative facilities, it organised and financed the large-scale and long-time work required, and made a present of the results to all users of boilers and steam plant.

It is probably in the field of dielectrics that the Electrical Research Association made its most important initial contribution to the unspectacular improvement of technique and standardization. One experienced manufacturer said recently that "The user nowadays is apt to take for granted the excellence and suitability of materials now available, whereas a glance backwards by the older members of the profession will undoubtedly remind them of the terrible 'try and try again' methods which were involved in any new design. Nowadays the designer knows exactly what to expect and is morally certain that if he specifies it he will get it. All this he owes very largely to co-operative research."

Research on materials, if it is to have practical value, requires the co-operation of craftsmen and technicians; but it has also afforded the Electrical Research Association its best opportunity for demonstrating the necessity of enlisting the help of workers in fundamental science. Fortunately most of the problems fall under the head of the 'theory of the solid state', one of the live issues in scientific research and involving in practice as well as principle all material properties. Research of a high order has been done by members of the staff, but emphasis should be placed on the assistance obtained from many leading figures in the world of pure science. To mention only a few heads of research institutes or departments under whom the Association's programmes have been carried out, we have the following physicists and chemists: Sir Lawrence Bragg, (the late) Prof. H. L. Callendar, Dr. C. H. Desch, Sir Alfred Egerton, (the late) Sir John Fox, Prof. N. F. Mott, Prof. W. Sucksmith and Prof. A. M. Tyndall. Of particular interest is the value derived from theoretical physicists working independently in those fields where lack of basic principles was retarding progress, and it is pleasing to note the growing realization that theoretical physics is as necessary in industrial applications as is experimental science. The importance of mathematics in industrial problems where text-book simplifications rarely apply led to the strengthening of the Association's resources in this respect, when the need was still inadequately recognized by most practising engineers. In all these efforts it has been a source of great encouragement to note the readiness with which leaders in other fields are willing to co-operate as soon as they find that the work is being done for the common good.

Researches on the phenomena of circuit breaking and on surge phenomena have resulted in revolutionary ideas, based upon scientific theory. In both fields it is probably true to say that the electrical industry has not yet felt the full impact. In the field of circuit breaking, however, the advances made are so varied as to parallel almost all those made in other industrial countries. The majority of heavy-power circuit breakers manufactured in Great Britain in recent years have been made under licences from the Association, and are unequalled for reliability of performance. The results of nine years work on surge phenomena, conducted on an adequate scale under the stimulus of financial support from the Central Electricity Board, have recently been published in book form, and establish not only a reliable basis for technical practice and plant design but also important progress in the problem of the lightning flash and in more recondite cosmic phenomena.

The extension of the amenities of a supply of electricity to rural areas presented many new problems and afforded an ideal field for co-ordination of considerable but unrelated effort. Before the War, investigations leading to simplification and standardization of practice in distribution were well advanced, and the best methods of applying electrical power to many activities in farming and horticulture were under investigation. The needs of the war and post-war periods emphasize the value of this contribution to food production.

It is impossible to touch upon many fields of work in which there has been good progress; but mention may be made of an investigation of fire-fighting methods adapted for safe use with electrical plant, which was completed in time to be of great service during the unforeseen effects of modern war. A topical feature is the Association's incursion into the field of domestic space- and water-heating, which well repays the scientific approach.

The research atmosphere in committees provides neutral ground for the free discussion of technical difficulties, but neutrality is apt to disappear when the investigator discovers an error in established practice. The demonstration that one or two spectacular tests of a large circuit breaker proved nothing as to its proper commercial rating was vigorously rejected at first, but eventually led to a great increase in testing facilities and corresponding improvements in the product. Great savings in expenditure on electric cables, the result of research, did not commend the Association in some quarters, but eventually assisted the rapid expansion of manufacture and use by the resulting reduction in the cost of electrical distribution. The regulation of voltage was regarded as the proper business of the station engineer, until it was found that a scientific study of the problem shed useful light both on the economic and technical aspects in relation to the advantages of a reasonably constant voltage for electrical appliances. There was recently some fear, now largely resolved, of the possibilities of a scientific analysis of matters which might throw light on the formulation of economically sound tariffs. The Electrical Research Association was discouraged initially from publishing its discovery that oil gas could be replaced by air in circuit breakers, save as a laboratory experiment, and it has taken about twenty years for the industry to absorb the resultant inventions.

The Electrical Research Committee had no laboratory or research staff. Its business was to organise co-operation between all branches of the industry and to plan and place out research work. The British Electrical and Allied Industries Research Association, to give the Association its full title, in continuation of this policy, at first placed out all its researches with member concerns, the National Physical Laboratory, the universities, technical colleges and individual experts. Soon, however, facilities were required which could not be found in this way; for example, access to large generators, traction batteries, overhead lines and other plant under working conditions. Thus, while still avoiding unnecessary duplication, the Association found it necessary to obtain a staff of its own and to provide temporary accommodation for personnel and apparatus. In this way there was accumulated a quantity of specialized equipment adapted for field investigations; for example, a multi-element oscillograph with high-speed camera and contactor gear housed in a trailer. A good example of co-operation occurred when a transportable high-voltage oscillograph and generating gear was required for studies of surge phenomena: the several interested manufacturers pooled all their ideas and information so as to secure the best possible instrument in the common interest, and then submitted competitive quotations for its manufacture.

After about twelve years, it was found economical to establish a single centre as headquarters for the Association's field work and accommodation for the Association's experimental research staff. This 'auxiliary laboratory' was put in hand at Alperton, to be opened by H.R.H. the late Duke of Kent in 1935. Meanwhile the Association continued to increase its operations in a geometric progression until the quantity of research placed out was proving an embarrassment to those asked to assist. Thus it was found necessary to extend the laboratory and the staff, so that at the beginning of the War the larger part of the Association's work was being carried out by its own staff.

During the War, thanks to the support of the Department of Scientific and Industrial Research, the Association, by then fully established as an essential part of the electrical industry of Britain, was able to continue its services to industry in the national interest as an 'essential undertaking'. At the same time its unique facilities and liaison with industry was gradually recognized by the Services and Supply Departments, so that about one third of the work at the Laboratory was carried out under direct contract with them. Several members of the staff were lent to the Service Departments, under conditions that enabled them to keep contact with the Association and utilize its facilities. Much of the work done is of interest solely to those directly concerned, but mention may be made of contributions to communication interference suppression, mine- and bomb-location, radio components, degaussing, opencast coal prospecting, and finally the design of the electrical equipment of tanks, which eventually came largely under the control of the Association's staff. Two inter-Service and manufacturers committees were organised by the Association, one on capacitors and the other on automobile ignition systems. The proportion of new projects to reach some degree of successful operation may be claimed to have been exceptionally high. This work came under the supervision of Dr. S. Whitehead, who, at the turn of the Association's twenty-fifth year, succeeded the present writer as the second director of research.

Apart from a discontinuity in the first three war years, the Association's income has been an exponential function of its age, roughly doubling every eight years or so; it started at about £15,000 in 1920 and was approaching £150,000 in 1945. About 80 per cent both of the manufacturing and supply sides of the industry, based on wages and revenue respectively, support the Association, which enjoys also a very gratifying number of members in the British Commonwealth overseas, together with a substantial membership in allied industries. During the War the Alperton site of 1¾ acres became clearly inadequate to cope with essential post-war developments or indeed with the accumulation of deferred work, so a site of 48 acres has been purchased at Leatherhead. Here, in company with certain other research associations, it is hoped to set up an establishment appropriate to a growing industry, the needs of which outstrip the trained personnel available and to which the pooling and planning of research will become of ever-increasing importance.

INFLUENCE OF CARBAMIC ESTERS (URETHANES) ON EXPERIMENTAL ANIMAL TUMOURS

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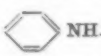
IN a comprehensive joint investigation of the action of various compounds upon the growth of experimental tumours, attention was paid to that heterogeneous class of substances which have from time to time been reported as producing effects upon the mitotic cycle ("le syndrome mitoclasique"[1]) either in animals or plants. Among these substances, the caryoclastic poisons of Dustin and his school[2], ethyl phenylcarbamate ('phenylurethane') (I) and its

I: Ethyl phenylcarbamate ('phenylurethane')

derivatives were selected for special study, particularly on account of the results obtained in another investigation, carried out in the laboratories of Imperial Chemical Industries, Ltd., by Templeman and Sexton[3], of the effect of arylcarbamic esters and related compounds upon cereals and other plant species. This study confirmed the observations of Lefèvre[4] on the morphological effects of ethyl phenylcarbamate on wheat seedlings, and extended them to include oats, barley and rye. Lefèvre had described these morphological changes as bulbous hypertrophies of the coleoptile, the mesocotyl and the root-tip, with progressive retardation or even arrest of growth: the underlying cytological alterations he interpreted as a blocking of mitosis in pseudo-metaphases, leading to irregular formation of monstrous restored nuclei. In comparisons of the potency of some fifty related arylcarbamic esters and thiocarbamates, Templeman



II: Isopropyl phenylcarbamate

and Sexton found isopropyl phenylcarbamate (II) to be approximately three times as active, in this sense, as ethyl phenylcarbamate: they regarded its effect on nuclear division as probably similar to that of colchicine, and in view of the low concentrations sufficient to arrest growth, suggested the use of this compound in the eradication of graminaceous weeds. Among compounds possessing no such activity were included methyl carbamate, ethyl carbamate (urethane), and formanilide. Apart from the references already cited, there is of course an extensive literature dealing with the suppressive action of urethane, phenylurethane and other carbamates on growth-processes, as in bacteria, protozoa, sea urchin eggs, plant tissues, and animal tissues growing *in vitro*; while other effects studied include the curious property of urethane in inducing pulmonary adenomata in mice[5], its action in increasing the potassium content of bronchial secretion in the cat[6], its toxic action upon the rat liver[7], and an alleged antagonism towards the action of sulphanilamide in luminous bacteria[8]. It is perhaps rather surprising, therefore, that so little attention appears to have been given to the action of urethane and related substances on the growth of tumours.

In our earliest experiments, the administration of phenylurethane was seen to produce the following undoubted effects in animal tissues. First was observed a transient increase of the mitotic count in the crypts of Lieberkühn in the mouse gut: so far as could be judged, this effect was not attributable to retardation of the mitotic cycle at any single phase, and it was clearly distinguishable from the characteristic effect produced in the same tissues by colchicine. Although Lefèvre had claimed that phenylurethane produces mitotic effects exactly similar to those described for colchicine, our impressions are more in keeping with the recent conclusion of Deysson[9]: "le phényluréthane et la colchicine sont actuellement les deux corps agissant sur les cinèses de la façon la plus voisine, et cependant nous venons de montrer qu'il existe de nombreuses différences dans la modalité de leur action".

Secondly, phenylurethane (and also isopropyl phenylcarbamate) was found to cause a significant retardation of the growth of spontaneous mammary cancer in the mouse, an effect which persisted only during administration, and passed off rapidly when the drug was withdrawn. Fig. 1 shows the retardation produced by phenylurethane in the growth of one such tumour, which had earlier been treated with αβ-dipiperonylethylamine hydrochloride, but with negative result, in another investigation (with Prof. G. A. R. Kon) of various diphenylethylamines and related substances stated by Lettré and Fernholz[10] to mimic the action of colchicine.

Thirdly, both ethyl and isopropyl phenylcarbamates produced a similar retardation in the growth of the Walker rat carcinoma 256. That there is no parallelism between these results and the findings of Templeman and Sexton in relation to cereals was indicated by the somewhat unexpected observation that all these effects are also produced by ethyl carbamate (urethane) itself ($NH_2.CO.O.C_2H_5$), the inhibitory activity of this substance being actually greater than that of either of the phenylcarbamates when tested against the Walker carcinoma. Some indication of the degree of this effect is shown in the accompanying table. (It should, however, be pointed out that although urethane showed no effect on plants such as was obtained with the phenylurethanes, differences due to such factors as cell permeability or metabolic changes in the drugs *in vivo* have not been considered, and hence there may well be a common factor in the chemical mechanism underlying the biological effects produced in plants and animals.)

EFFECT OF ETHYLCARBAMATE ON THE GROWTH OF THE WALKER RAT CARCINOMA 256. INDIVIDUAL TUMOUR WEIGHTS (GM.) 16 DAYS FOLLOWING IMPLANTATION.

Control series (12 intra-peritoneal injections of solvent over 14 days)	Treated series (12 intra-peritoneal injections of 50 mgm. ethylcarbamate in aq. solution over 14 days)
39·7	8·7
34·8	8·0
32·3	6·7
32·0	4·3
30·9	4·0
27·1	3·9
27·0	3·8
24·2	3·3
22·3	2·9
17·9	0·3
12·0	0·2
5·7	

This action of urethane upon the growth of the Walker carcinoma was next found to be accompanied by a profound modification in the histological struc-

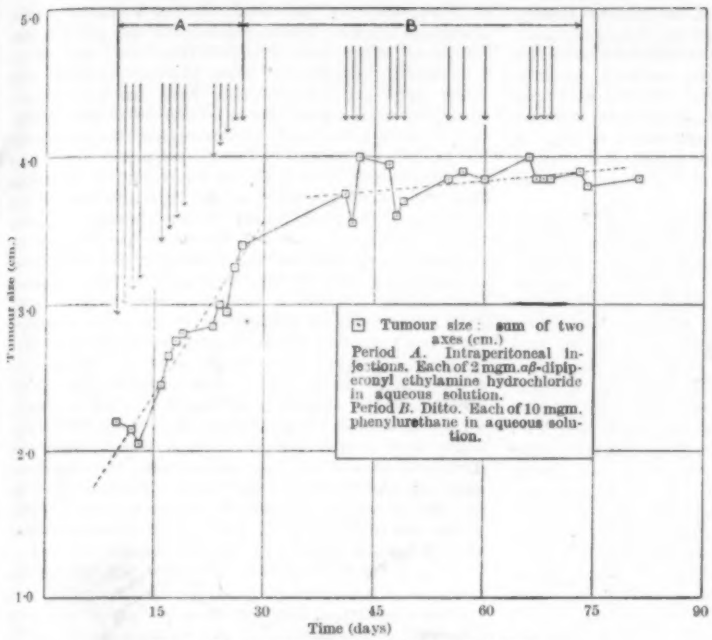
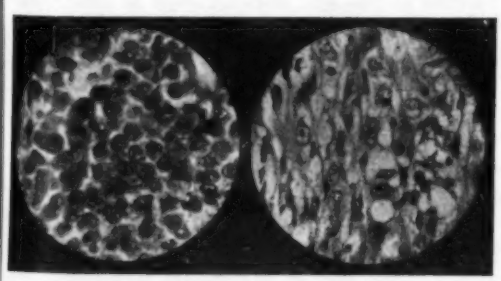


Fig. 1. Spontaneous Mammary Cancer in Mouse.

ture of the tumour, of a kind which had not thus far been encountered in very numerous comparable experiments representing a large number of compounds of other chemical types. From Fig. 2 (*A* and *B*) it will be seen that under the influence of urethane the characteristic cellular texture gives place to a more fibrous structure, with spindle-cells and a distinctly abundant stroma. While precise interpretation is difficult, the impression was gained that the alteration involves, in part at least, some attempted differentiation, and is not altogether to be ascribed to secondary changes involving the vessels and stroma only.

Although the growth effects above described were in no way dramatic, their reproducibility, and the interest of the circumstance that they might be brought about by a known substance as simple and as readily available as urethane, suggested the advisability of testing their action in advanced and inoperable or otherwise intractable cancer in the human subject. Clinical trials, using urethane and isopropyl phenylcarbamate, were accordingly started in 1943, first at the Royal Cancer Hospital (Free), and afterwards in collaboration with the Christie Hospital and Holt Radium Institute, Manchester. The results of these early trials, mainly referring to carcinoma of the breast and a miscellaneous group including other types of malignant disease, are summarized in a paper elsewhere[11]. Briefly, while indications of slight amelioration attributable to treatment were observed in a small proportion (for example, in three cases of carcinoma of the breast, and in single cases of lymphosarcoma, Hodgkin's disease, and recurrent mixed salivary tumour of the antrum), the results were mainly negative. It was, however, decided to pursue the investigation for a further period. In that part conducted at the Christie Hospital it was next observed, by Dr. Edith Paterson, that urethane produced a fall in the leucocyte count in some of these cases, following which the clinical trial was extended to include examples of leukæmia and other lymphadenopathies. From the clinical results it is obvious that although the results of urethane therapy are not entirely restricted to leukæmia, they are vastly more pronounced in that disease, whether myeloid or lymphatic, as is shown in favourable cases by the rapid decline in the white-cell count to normal limits, by the tendency for the differential count to revert at least towards a more normal composition, and by diminution in spleen size and glandular masses. These effects, while they may occasionally persist for a variable time after urethane withdrawal, are, however, essentially reversible, agreeing in that respect with those produced in various animal tumours as described above.



A *B*

Fig. 2. Histology of the Walker rat carcinoma: (*A*) Normal appearance, × 300; and (*B*) after 12 × 50 mgm. urethane in 14 days, × 270.

Possible Modes of Action of Urethane

The remarkable effects of urethane in leukæmia, and indications from other experiments (to be published elsewhere) that the growth-inhibitory influence of urethanes upon the Walker rat carcinoma is restricted to a few such substances, and is certainly not exhibited by the great majority of a long series of related compounds, raise interesting problems as to its mode of action. Although these inhibitory effects appear not to be related to narcotic properties, at any rate in any simple fashion, it might be expected that assistance could be obtained on this point from the vast pharmacological literature dealing with urethanes and narcosis generally. It was recorded by Warburg[12] so long ago as 1910 that if phenylurethane (*c.* 1/2,000 *N*) is added to sea water containing eggs of the sea urchin *Strongylocentrotus lividus*, cell division and nuclear division are suppressed, while the oxygen consumption is only very slightly reduced; and Clark[13] found the inhibition of cell division in similar material by urethane to be an all-or-none effect, in contrast with a graded inhibitory action on respira-

tion. Later, Warburg[14] advanced the general theory that narcosis is due to adsorption of the narcotic in unimolecular layers on the catalytic surfaces involved in oxidation: but others have the contrary opinion, that urethane narcosis cannot be attributed to simple adsorption[15]. Even so it is clear, as has been pointed out by Quastel[16], that if the character of a drug of this kind determines its entry into a cell, or its orientation at a surface, this alone can give no obvious clue to its mechanism of action.

The next interpretation, an attempt to relate both narcosis and inhibition of cell division with a general inhibition of dehydrogenases, is faced with the difficulty that the concentrations required to induce narcosis, and often to suppress growth, or likely to be met with *in vivo*, are often far smaller than those required to inhibit enzyme reactions. Keilin and Hartree[17] found that urethane and other narcotics, which in presence of biological reducing systems inhibit the reduction of the cytochrome components a, a_3 and c, inhibit, on the contrary, the oxidation of b; and they suggested that the effect of urethane consists in bringing about the formation of a not easily dissociable complex composed of dehydrogenase, substrate and cytochrome b, and so making it inaccessible to the portion of the system reacting with oxygen. Quastel also put forward the qualified view that the inhibition of respiration of brain tissue obtained by low concentrations of narcotics under aerobic conditions is due not to competition of the narcotic with substrates for their dehydrogenases, but to the affinity of the narcotic to a special component playing an important part in the complete respiratory process of the cell—the narcotic effect being restricted at low concentrations to a tissue component which is possibly a flavoprotein. It is of interest here that the 'activity system' of Fisher and Stern[18] (that is, that portion of the overall respiration which is most sensitive to inhibition) appears to be associated with the maintenance of normal mitosis, for when it is differentially suppressed by appropriate urethane concentrations, abnormal nuclear figures appear[19]. In a special case, Johnson *et al.*[20] have recently systematized our present information regarding the relation of luminescent oxidation to the respiratory pathway in bacteria, and the inhibitory influence of urethane thereon: the luminescent system shows a characteristic sensitivity to urethane and is affected to a much greater extent than total oxygen consumption.

When our earlier results were being considered, it was suggested (by Prof. A. R. Todd) that urethane might conceivably act by competing with some natural amine involved in the biosynthesis of nucleotides: such a possibility is clearly of interest in connexion with the belief of Plentl and Schoenheimer[21], that since neither purines nor pyrimidines in the diet are utilized for the synthesis of nucleoproteins, these substances may be built up from smaller molecules within the nucleus. The possibility that urethane may act by inducing a deviation in purine synthesis becomes even more suggestive, at least as a tentative hypothesis, in view of the long recognized aberration of purine metabolism in leukæmia[22], and speculations regarding a relationship between leukæmia and uratosis in subjects carrying a latent tendency to gout[23]. Here may be mentioned several papers of more than forty years ago, which are highly intriguing in the present context, and also in view of current interest in the significance of nucleoproteins for cellular differentiation. Following a description by v. Moraczewski of the metabolism in a case of chronic leukæmia showing marked nitrogen- and phosphorus-retention, White and Gowland Hopkins[24] carried out a similar investigation. They thought it likely that when large numbers of new cells are present (for example, myelocytes), some of the diminished excretion of phosphorus is due to retention "to provide for the nuclein of the newly formed corpuscles". Milroy and Malcolm[25], in a study of excretion in leukæmia, and the intracellular 'nuclein' metabolism of the granular leucocytes, found "more phosphorus being taken up than given off by these cells", but regarded as hypothetical the view that the diminished excretion of phosphorus was due to its retention for nuclein synthesis in the newly formed cells. In a later study of the origin of uric acid, Plimmer, Dick and Lieb[26] quote an observation by Horbaczewski, which they were able to confirm, of a relation between the number of leucocytes in the blood, and the output of uric acid: it was found (in a normal subject) that the uric acid output was high when the white cell count was raised, and that disappearance of the leucocytes from the blood was associated with a fall in the output of uric acid. They did not, however, consider purines (arising from the white cell nuclei) as the precursors of the uric acid, as had been supposed by Horbaczewski.

It is a further question whether the exceptional response of leukæmia to urethane may reflect either a special sensitivity of leukæmic cells to inhibition (thus Stamer[27] states that the carcinogenic hydrocarbon 9 : 10-dimethyl-1 : 2-benzanthracene, which has only slight retarding action when tested against many animal tumours, is in fact capable of eradicating transplanted leukæmia in mice: he also finds that the leukæmic cells are more sensitive to this substance than are normal leucocytes), or unusual metabolic properties in leucocytes whether normal or malignant: here it must be borne in mind that while normal white cells are certainly susceptible to the action of urethane[11], they are relatively much more refractory than are leukæmic cells. It was found by Fleischmann[28] that when respiration was fully inhibited by hydrocyanic acid, the phagocytic and amœboid functions of leucocytes were fully retained, the necessary energy being derived from glycolysis ('anoxybiotic activity'); and Glover *et al.*[29], although describing a relation between oxygen consumption of leukæmic cells and the degree of their maturity, believed there is no fundamental difference between the metabolism of leukæmic cells and that of normal white blood cells. A more recently discovered finding, which may be significant, is the presence of abnormal amounts of thiamine in leukæmic cells, with contrasts between normal and leukæmic cells in their metabolism of pyruvate[30].

Thus much of the information at present available is only vaguely suggestive as to possible mechanisms through which urethane may produce growth-inhibitory effects, as manifested most strikingly in its action upon leukæmic cells. Investigations of the purine metabolism in several of the cases reported by Paterson *et al.* have not as yet been sufficient to yield any useful data, largely because in none of them was the uric acid content of the blood unduly raised before treatment. It is, however, a striking circumstance that colchicine, which was earliest employed for its action upon gout, then observed to produce effects upon the bone marrow[31], later found to have its remarkable influence on mitosis, and since known to have some action in leukæmia[32], should be imitated

by arsenic both in the treatment of leukæmia[33] and in effects on the mitotic cycle[34], and now to some extent by urethane in leukæmia and on cell division. It is an important problem whether the primary action of urethane is upon the growth mechanism or upon differentiation processes—to the extent that these are separable. That the latter is more likely is indicated from the marked histological and cytological changes in the Walker rat carcinoma which are produced by urethane. Although these alterations are associated with a moderate degree of inhibition of growth, it is certain that a much more intense retardation, repeatedly observed in independent experiments following administration of many other compounds quite unrelated to urethane, is not accompanied by any such marked effects upon cellular differentiation. Hence these effects may be regarded as due to a characteristic property of urethane, and it is perhaps reasonable to suspect that the drug may act on growth primarily through the processes of maturation, and in leukæmia by tending to remedy some deficiency in these processes. It is likely that more precise information must await the application, for this problem, of recent improvements in cytological technique as they affect the study of mitosis and differentiation in the cells of the marrow and blood[35].

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ORIGIN OF THE FIRST EUROPEAN POTATOES AND THEIR REACTION TO LENGTH OF DAY

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AMONG the consequences of the recent Russian expeditions to South America was a revival of interest in the origin of the European potato. There are two centres from which potatoes might have come: the Chiloé region of South Chile, and the Andes at tropical latitudes. Bukasov[1] and his co-workers chose Chile, partly for morphological reasons which by themselves were insufficient, but primarily because the Chilean potatoes are adapted to long summer days, whereas the Andean potatoes are suited to the approximately twelve-hour day of the tropics and, as a rule, fare badly if grown in Europe during summer. But Salaman[2] pointed out that at the time when potatoes were known in Europe the Spanish hold on Chile was tenuous, and Magellan had not yet navigated the Straits; it was unlikely either that the Spaniards could have acquired the potato in Chile or, if they had, that they could have brought it safely over the slow route home. On grounds of probability, it was much more likely that they took potatoes from Colombia, Ecuador, Bolivia or Peru, which had been conquered half a century earlier and which were in constant touch with Spain. On the question of photoperiodism, Hawkes[1] suggests in support of this hypothesis first, that the first European potatoes may have been long-day or day-neutral types, since these occur occasionally among Andean varieties; secondly, that if they were short-day types, their character might have been changed by breeding, as Salaman[2] suggested earlier; and, thirdly, that if they were short-day types, they might not have done too badly at the fairly low latitudes of southern Europe, to which they first came.

Thus the Cambridge school, however much it differs on the main issue, at least agrees with the Russian in assuming that short-day Andean types would have been ill-adapted to European conditions, and postulates that if a short-day reaction existed in the first European potatoes, it was something to be removed as early as possible. This view is unacceptable; all the evidence which will be presented from various sources is entirely consistent in showing that the first European potatoes were grown in short days, that they were in fact short-day varieties, and that short-day varieties persisted not just for a short while but for centuries.

From Salaman's history of the potato[2] one learns that the first-known record in Europe is in the account books of the Hospital de la Sangre at Seville. In 1573 and subsequent years, potatoes were bought as part of the normal housekeeping, always in the last quarter of the year. This Salaman regards as good evidence that they were grown in Spain and eaten freshly harvested. But it is more than this. It is good evidence that they were grown in the short days of autumn or early winter; indeed, if they were grown locally, they were almost certainly grown as an autumn crop, because the Andalusian summer is far too hot for potatoes. When we next hear of the continental European potatoes, they are still being grown far into the autumn: Clusius[1], who obtained

potatoes in 1588, describes them as ripening at Vienna in November.

As regards climatic evidence, little need be said of the other Mediterranean countries to which the potato spread at an early date. In them, as in Spain, an autumn crop under roughly equinoctial conditions is quite possible. Moreover, on Rasumov's evidence[5] that 30–40 days' growth in short days at the start will enable a short-day variety to develop tubers as if it was under short-day conditions for the rest of its life, short-day varieties could have been used around the Mediterranean for an early spring crop as well.

More important for this discussion is the climate of Ireland, where potatoes first achieved national importance in Europe, and of the rest of the British Isles and north-western Europe where the Atlantic influence prevails. Two features of the climate are significant. Seasonal changes of temperature are relatively small, so that the autumns are mild, despite the northerly latitude, and summer temperatures low enough to be about optimal for potatoes; and temperatures lag behind the solar seasons, so that August is as warm as July, and September, the month of the autumn equinox, as warm as June, the month of the longest day. The season is both long and late, and potatoes can be grown deep into the autumn. Modern circumstances may obscure this point to some extent, but in the centuries before blight arrived there was no real haste to plant early, and potatoes were not grown on a large enough scale to make catering for an early market or early harvesting before the autumn rains soaked the soil—a matter of much importance. In 1699, more than a century after potatoes came to Britain, Evelyn was still able to recommend harvesting in November, while in 1836, a few years before blight arrived, Lawson's "Agriculturalist's Manual", published in Edinburgh, listed, among other varieties, "late field potatoes, the foliage of which in ordinary seasons does not decay until injured by frost and the tubers of which generally require to be kept for some time before being fit for using to the greatest advantage", and large late prolific sorts for feeding cattle. By Lawson's time, many early varieties had been developed and the general pattern of potato farming had changed in consequence; but it is possible that among the late varieties were types not very different in behaviour from the original European potatoes. Evidence on this point is found in the potatoes from Basutoland, which will be described later.

Growth through the autumn would allow short-day varieties to be cultivated in north-western Europe, but they would probably not behave as modern varieties do. Vigorous development of stolons could be expected during the long summer days, and the setting of the crop would not really start until about the end of August, though varieties would vary considerably in this respect. Nowadays behaviour of this sort would put a variety beyond the pale; but this is beside the point, because the fact is that for a long time potatoes were wildly stoloniferous and slow maturing. For many years Europe was without early varieties or varieties meeting modern standards for stolons.

In Ireland the climate is intensely maritime; and nowhere in Europe is the climate finer for potatoes. What is more to the point, nowhere in northern Europe were conditions more favourable to autumn growth at a time when blight was absent and large-scale cultivation not begun. In the west of England and in Wales the climate is also strongly maritime and autumn temperatures mild, and the potato was also adopted here at an early date. It is not suggested that climate was the only factor involved—as Salaman[6] has pointed out, the enclosure of land in the west of Britain favoured the potato while the open-field system in the east hindered its cultivation—and all that now concerns us is that, in northern as in southern Europe, where the potato first went, conditions there permitted growth late in autumn.

As one goes eastward in northern Eurasia, seasonal changes become greater. At the same time, temperatures follow the solar seasons more closely and reach their peak in July, after which they decline. Where the summers are cool enough to favour potatoes, frost comes early, often before the autumn equinox. In these conditions there would be substance in the objections which have been raised against short-day varieties, but since potatoes were scarcely known in north-eastern Europe until about two centuries after they came to Spain and Britain, the objection is not material.

The points we have considered are circumstantial evidence that the first potatoes were short-day types. More direct evidence is given by the potatoes of Basutoland, which can be regarded as relics of the potato as it existed in Europe before blight wiped out most old varieties and started a spell of breeding which gave us potatoes as we know them to-day. Documentary evidence of their introduction is available: the Rev. E. Casalis described in his autobiography[7] how in 1833 he went as the first missionary to the Basuto, then a young tribe miles away from white civilization. In the same year he went back to Phillipolis and returned to Basutoland with seed potatoes which were multiplied and distributed. As the Basuto nation grew, it carried its potatoes with it among the mountains. But the potato was never more than a minor article of food, and the Basuto seem to have had just enough interest in the crop to preserve it (largely by tending ground-keepers) without troubling to improve the varieties or introduce new ones; and although Up-to-Date has been grown all around Basutoland for fifty-odd years, it was not seen once in a 'native' condition during a fairly extensive survey, although it is common in traders' gardens and the like. At least a dozen varieties have survived (most of which have been added to the Empire Potato Collection at Cambridge), all of them showing primitive characters like deep eyes or long stolons. There seems to be little doubt of their European origin. Historically, the eastern Cape Colony, where there was a flourishing potato industry in the 1830's and of which Phillipolis was a missionaries' outpost, had close contacts with Europe. Morphologically, the varieties have strong affinities with the European potato; they would not have been out of place among the varieties which were described in Europe early last century and which we know from contemporary records to have been numberless[8]. Where they differ from the few survivors of that period now still grown in Europe is that the Basuto, with their general indifference to the potato as a food, have kept the poor varieties as well as the good, whereas the European has long since discarded the poor, which, to judge by the literature of 100–150 years ago, were far too common.

What concerns us here is the short-day reaction of many of the Basutoland varieties. Although the latitude is only 30° S. (which is lower than that of

southern Europe), the summer days seem too long for some varieties which develop a mass of stolons but few tubers before the autumn. In the middle of February, about five weeks before the autumn equinox, one variety (No. 167) was apparently without tubers at all, although the plants had obviously been flowering a long time; to get specimens, it was necessary to remove an old sett and re-plant it in Pretoria, where tubers were rapidly formed in winter. Another variety, grown at the Quthing Experiment Station, was also without tubers at that time, although the plants were months old and had a great bulk of stolons; two plants were marked, and from them the agricultural and livestock officer was able to send about 6 lb. of tubers, all of which must have developed before frost came at the end of April. Several other varieties were not quite so late, but nevertheless had only small immature tubers at the end of the long stolons at the middle of February. Three of them—Nos. 148, 158 and 164—were grown in Pretoria (latitude 26° S.) during winter, with non-luminous heaters to protect them against light frost. They grew without long stolons and yielded respectively 2·5, 5 and 6 times as much as when the days were lengthened to 18 hours with electric light.

The Basutoland potatoes show that a short-day reaction existed in the domestic potato down into the nineteenth century. This reaction may still persist to the present day in European maincrop or late varieties. Tincker[9] found it in the variety King Edward; and experiments in Pretoria, in which normal winter days were compared with days lengthened to eighteen hours by artificial light, showed that Up-to-Date and Kerr's Pink yielded slightly better when grown to maturity under the short-day conditions, though they were not far off day-neutral and showed nothing of that great delay in forming tubers in long days which is characteristic of many Andean and Basutoland varieties. These three varieties seem to be the only three European maincrop varieties, as distinct from earlier varieties, which have been tested, and there is no reason for believing they are atypical.

The Chilean varieties are generally regarded as having a long-day reaction, and the evidence of photoperiodism, far from supporting the view that the European potatoes came from Chile, is strongly against it. This position will not be altered even if, as seems likely, further work shows that late-maturing varieties from Chile have a nearly day-neutral rather than a long-day reaction.

A point of nomenclature remains. The name *Solanum tuberosum* was given to the European potato by Bauhin in 1596 and retained by Linnæus. Recently Juzepczuk and Bukasov grouped the Andean tetraploid varieties in a new species, *S. andigenum*. Hawkes[3], although supporting Salaman's theory that the European potato came from the Andes, kept the name *S. andigenum* on grounds of convenience. But since *S. andigenum* was separated from *S. tuberosum* largely because the Andean potatoes have a short-day reaction and since, on the evidence given here, the European varieties known to Bauhin and many of those known to Linnæus must also have had this reaction, this seems to be carrying convenience too far. No doubt keeping the name *S. andigenum* helped Hawkes to make his account of the Imperial Agricultural Bureaux potato collecting expeditions as lucid as it is, but those of us with no arduous task of compilation might well use the name *S. tuberosum*, whether it be for Peruvian varieties or Polish, Andean varieties or European, and leave it at that.

[1] Bukasov, S. M., Suppl. 58 Bull. Appl. Bot. Leningrad, pp. 192 (1933), quoted by Salaman, Hawkes and others.
[2] Salaman, R. N., *J. Roy. Hort. Soc.*, **62**, 61, 112, 153, 253 (1937).
[3] Hawkes, J. G., "Potato Collecting Expeditions in Mexico and South America". Imp. Bur. of Plant Breeding and Genetics, 142 (1944).
[4] Clusius, C., "Rariorum plantarum Historia" (Antwerp, 1601).
[5] Quoted by Hackbarth, *J. Züchter*, **7**, 95 (1935).
[6] Salaman, R. N., *New Biol.*, **1**, 9 (1945).
[7] Casalis, E., "My Life in Basutoland". English trans. by Brierley. Religious Tract Soc. (London, 1889).
[8] For example, see Loudon, J. C., "Encyclopædia of Gardening", p. 829 (London, 1835).
[9] Tincker, M. A. H., *Ann. Bot.*, **39**, 721 (1925).

OBITUARIES

Prof. A. E. Dixon

An Act of Parliament to endow new "Colleges for the Advancement of Learning in Ireland" was passed in 1845. In a few years, university colleges were established at Belfast, Cork and Galway, and in 1849 the first professor of chemistry of the Queen's University of Ireland at Cork, Dr. John Blyth, was appointed. He was followed in 1873 by Prof. Maxwell Simpson, and in October 1891 by Dr. A. E. Dixon. A new charter in 1908 changed the status of the College to that of a constituent college of the National University of Ireland, and Dixon retained his professorship. In 1925, after thirty-three years service, he became emeritus professor, a title which he retained until his death on March 3, 1946. A period of practically a century is covered by these three chemists.

Augustus Dixon was born in Belfast in 1860, the eldest son of Wakefield H. Dixon. He received his early education at the Royal Belfast Academical Institute and went to Trinity College, Dublin, in his twentieth year. In 1882 he entered for the honours course in experimental science and qualified in 1885 with a T.C.D. Senior Moderatorship and a gold medal in experimental science. At this period there was an active chemical school in Trinity directed by Prof. Emerson Reynolds; Dixon soon came under its influence and decided to make chemistry his profession. On the advice of Reynolds he followed the procedure very prevalent at this period and entered for a medical degree before specializing in chemistry. He obtained the Ekenhead Scholarship in Experimental Science and also a medical scholarship. During his medical course he kept in close touch with chemical research. Immediately after obtaining his M.D. degree, he went to the University of Berlin for a year and received a thorough training under Prof. A. W. Hofmann. In 1887 he became assistant lecturer in Trinity College, Dublin, and in the following year was appointed professor of chemistry in Queen's College, Galway, and served there until his transfer to Cork in 1891. It is of interest to note that he had direct association with four chemical schools in Ireland: Belfast, Dublin, Galway and Cork.

Dixon's first research, published in 1888 in the *Transactions of the Chemical Society*, was on the action of the isothiocyanates on the aldehyde ammonias. For a period of more than thirty-five years he investigated the chemistry of thiourea and related sulphur compounds. His record of some fifty

papers in the *Transactions* and *Proceedings of the Chemical Society*, mostly in his name alone, shows a fine, comprehensive record of systematic and accurate work on an important branch of organic chemistry—a branch now becoming increasingly important in connexion with the chemistry of plastics and drugs.

On a few occasions, Dixon, to confirm certain theories of his, had recourse to physico-chemical methods. He was an expert at mechanical operations and a first-rate glass manipulator. Further, he collaborated with Prof. Hartog on the chemical aspect of certain biological problems. In these activities also he was a master of his subject. Apart from his research ability, he was an excellent and stimulating lecturer; he followed the Hofmann tradition of showing many elaborate experiments in his undergraduate classes. He also took a keen interest in the erection of new chemical laboratories in University College, Cork, and was responsible for many novel ideas in their design and equipment.

Prof. Dixon was of a retiring disposition, and only his intimate friends were aware of his very active scientific life. He served for five years on the Council of the Chemical Society, London. He was also a member of a special research committee of the Royal Society. His hobby was photography, in which he was an expert, and he was one of the founders of the Cork Photographic Society. He was president of the Society until his departure to Sidcup, Kent, on retirement in 1924.

Dixon married Miss Nina Haughton, of Dublin, in 1888, and his two sons graduated at University College, Cork: Wilfred (who died soon after graduation) in medicine, and Emerson in engineering. He is survived by his widow, one son and a married daughter.

JOSEPH REILLY.

Dr. J. D. Rolleston

BY the death on March 13, at the age of seventy-three, of Dr. J. D. Rolleston, British medicine has lost a man who had an international reputation for his work on the clinical aspects of the infectious diseases, and in the field of the history of medicine. His friends had for some time noticed a gradual decline in his physical powers, and his death took place as the termination of a short illness.

John Davy Rolleston was the son of Dr. George Rolleston, Linacre professor of anatomy and physiology at Oxford. There 'J. D.' was born in 1873, and he was thus junior by eleven years to his brother Humphry, later destined to become the regius professor of physic at Cambridge, and president of the Royal College of Physicians. J. D. Rolleston was a classical scholar both of Marlborough and of Brazenose College, Oxford. His medical training was obtained at Charing Cross Hospital between 1895 and his qualification in 1900. He graduated M.D. (Oxon.) in 1904.

Rolleston spent practically the whole of his professional life as a specialist in the acute infectious diseases. Between 1902 and 1930 he served in three of the hospitals of the Metropolitan Asylums Board. Possibly his most intensive period of literary activity in the clinical field was reached while he was senior assistant medical officer of the Grove Fever Hospital. In 1926 he became medical superintendent of the Western Fever Hospital at Fulham, and he retained this position after the M.A.B. hospitals were transferred to the London County Council, and until his retirement in 1938. He was an able hospital administrator and a clinician of great skill, whose interests and knowledge extended widely beyond the domain of the specific fevers.

It was in the field of medical literature that Rolleston's name became widely known in many countries. In 1925 he produced his exhaustive textbook on the "Acute Infectious Diseases", and other editions followed in 1929 and in 1940. At the time of his death he was working on a fourth edition. This book summarized the literature as few similar books have ever done, and the first-hand nature of most of the book is indicated by the fact that he quotes nearly ninety papers by himself alone on the various diseases. In the clinical field Rolleston also contributed freely to various abstracting journals, to the *Medical Annual*, and to the *British Encyclopædia of Medical Practice*; and he edited the *British Journal of Children's Diseases* during 1910–44.

Dr. Rolleston was also well known for his writings on the history of medicine. He was president of the Section of the History of Medicine of the Royal Society of Medicine, and in 1935–36 he delivered the Fitzpatrick Lectures before the Royal College of Physicians. These lectures were eventually published as "The History of the Acute Exanthemata". He was an honorary member of the Royal Rumanian Society for the History of Medicine and a member of the Société Française de l'Histoire de la Médecine. In 1922 he was general secretary of the International Congress of the History of Medicine which was held in London, and in 1925 he was vice-president of honour of the Geneva Congress. He was interested in several languages, and in French literature he was especially proficient. He was a life-long student of Voltaire, and he had published papers on the French philosopher.

Dr. Rolleston was a member of the council of the Society for the Study of Inebriety, and he did much important work in this field. During his later years he devoted a great deal of attention to the relations between folk-lore and medicine, and he was also a member of council of the Folk-lore Society. He had for long been a corresponding member of the Société de Pédiatrie de Paris. He had for many years been associated with the Royal Society of Medicine, and at one time or another he was president of four sections—history, children, epidemiology and State medicine and clinical—which possibly constitutes a record. After his retirement in 1938 he contributed to the journals no fewer than twenty articles on folk-lore and literary subjects. He had served as honorary librarian of the Royal Society of Medicine, and as representative of the Royal College of Physicians on the committee of management of the Chelsea Physic Garden.

Dr. Rolleston is survived by his widow, a son and a daughter.

E. ASHWORTH UNDERWOOD.

DR. W. J. C. ORR, who died on March 13, held an I.C.I. Fellowship in Chemistry at the University of Glasgow, having taken up this post in October last year. Previously he had held a research post with the British Rubber Research Association, and had worked in the Universities of Cambridge and Edinburgh. He was well known for his work in physical chemistry, especially on reactions involving isotopes, thermodynamics generally, and bond energies, on which subjects he had published a large number of papers.

NEWS and VIEWS

Prof. F. Wood Jones, F.R.S.

PROF. FREDERIC WOOD JONES retired from the chair of anatomy in the University of Manchester last December. Manchester has had the good fortune to house two pre-eminent anatomists of the century, the late Sir Grafton Elliot Smith (1909–19) and F. Wood Jones (1938–45). The former left Manchester for University College, London; and the latter has been appointed to the new Sir William H. Collins chair of anatomy at the Royal College of Surgeons. The Royal College is fortunate in obtaining the services of so travelled and so distinguished a follower of John Hunter to restore the Hunterian Collection which suffered so severely in the air raids on London. Moreover, Prof. Wood Jones maintains the broad biological interests which characterized John Hunter, to whom the animal and vegetable world were kin. As a traveller and scientific missionary he stands unique. He has taught in several London schools as well as at Manchester, and has held chairs in London, Adelaide, Hawaii, Pekin, Melbourne and Manchester. He has written classics in biology and anatomy. Every medical student knows his books on "The Hand" and "The Foot", and every biologist knows his "Mammals of South Australia". His association with Elliot Smith produced the "Archæological Survey of Nubia". Of recent years a stream of philosophical essays has come from his facile pen, and he has done much to keep the fundamental biological studies of John Hunter, Richard Owen and Lamarck before scientific workers.

Prof. N. D. Zelinskii

ON February 6, 1946, Nicholas D. Zelinskii, the most prominent chemist of the U.S.S.R., celebrated his eighty-fifth birthday. The following notes on his life are based on material sent by Prof. D. Rodionov. More than sixty years of original chemical work has made Zelinskii's name known and famous throughout the world. He was the first in Russia to emphasize the importance of the study of stereochemical problems, and he has made a personal contribution by his interesting investigations of stereoisomeric phenomena in the series of the saturated carbon compounds. In 1895 he began his classical syntheses of cycloparaffins, and discovered that naphtha of Russian origin is characterized by the presence of these compounds. This discovery opened a wide field to his numerous pupils and to other chemists, in the study of the natural naphthenes. Since that time, Zelinskii has continued to interest himself in this subject, and after leaving the chair of organic chemistry in the University of Moscow, he was instrumental in establishing a new chair devoted to cognate studies. He has made many important investigations with collaborators on the pyrolysis of naphthenes to aromatic compounds, on naphthabenzination, on the synthetic preparation of high-grade petrol, on catalytic processes for the improvement of the iso-octane number and on many other similar topics.

In 1911, Zelinskii began his work on catalytic hydrogenation and dehydrogenation and on heterogeneous catalysis. These studies were the starting point of a large number of later investigations by himself and his pupils in the field of organic catalysis. In the U.S.S.R. he was the first to form a great school devoted to the development of organic catalysis. He and his collaborators have also made a series of theoretical studies of the subject of great practical importance. His work on contact phenomena in relation to the chemical transformations of hydrocarbons, for example, on the transformation of six-membered rings into five-membered and on the cyclization of paraffins, must be mentioned in this connexion. His general method for the preparation of α-amino-acids and his original modifications of the methods of protein hydrolysis are of great interest. During the War of 1914–18 he devoted much effort to the improvement of the gas-mask; he was the first to propose active wood-charcoal for this purpose. This work led to further investigations on absorption in general and has been developed in the schools of his pupils and friends, Prof. N. A. Shilov and Academician M. M. Dubinin.

In spite of his age, Zelinskii is still very active. It may be sufficient to note that last year he made two interesting reports: (1) on the role of the Academy of Science in the historical development of organic chemistry, and (2) on the chemical investigations of Pasteur; and in January of this year he presented a paper on the nature of chemical organisation on the growth of the extremities of the axolotl. Zelinskii is the president of the Russian Society of Naturalists and takes a lively interest in the achievements of all branches of science.

U.S. Navy Hydrographic Office: Division of Oceanography

THE U.S. Navy Hydrographic Office has established a Division of Oceanography to provide for increased responsibilities in oceanography recently assigned to the Office by the Secretary of the Navy. Experience during the War indicated that oceanographic knowledge has now been extended to the limit in its practical application, and new techniques have opened up many possibilities of further fundamental investigations. By expanding its oceanographic work, the U.S. Hydrographic Office will be continuing its tradition of service to the mariner and will afford other agencies facilities for co-ordination of oceanographic observations and research. The Hydrographer intends to maintain a central oceanographic library, central files of oceanographic data (to be published in a special bulletin), and a bibliographic service, and to provide charts and manuals utilizing the results of the most recent research. In carrying out this work, the Hydrographic Office will not only make use of the services of its own personnel in the newly established Division of Oceanography, but also will give financial support to oceanographic institutions to permit them to expand their facilities for basic research of interest to the U.S. Navy and other Government agencies. In addition to publications of immediate practical use to mariners, the Hydrographer proposes to publish a series of technical studies which will be of interest to those working in applied oceanography as well as to personnel at research institutions in the United States and abroad. An advisory committee consisting of representatives of the U.S. Navy and other Government bodies is being formed to advise the Hydrographer concerning oceanographic problems of special interest to those represented, and to assist in co-ordinating government research in the United States in oceanography.

Pan-African Congress on Prehistory

THE Government of Kenya has agreed that a Pan-African Congress on Prehistory (Archæology) shall be convened in Nairobi, Kenya Colony, during January 11–February 1, 1947. The Congress will be concerned with the prehistory of the African continent, and the discussions will also include relevant subjects, such as those aspects of palæontology which intimately concern prehistory, climatic changes and quaternary geology in relation to prehistory. It is proposed that the Congress should be divided into two parts. The first three and a half days will be devoted to discussions upon problems of a general nature, including the following: terminology for the various pluvial periods and post-pluvial phases of the Pleistocene; terminology for the stone-age cultures in Africa; definitions of the words 'Pliocene' and 'Pleistocene' with the view of reaching an agreed definition throughout the African continent; co-operation in respect of research programmes in prehistory and allied subjects in the various African territories; protection of prehistoric sites and of other sites of connected interest; control of excavations; future of research into prehistory and allied subjects in African territories. The second part of the Congress will be devoted to the reading of papers and to discussions upon discoveries made in the field of prehistory since 1939, and more particularly to such discoveries as have had little publicity outside the territories in which they were made, owing to war-time conditions. Excursions to sites in East Africa are planned to take place both during the days immediately preceding the Congress and also during the week following the Congress. The former is designed to give delegates an opportunity of seeing the principal type sections upon which the pluvial and post-pluvial climatic changes for Kenya were originally based, and also to see some of the more important prehistoric sites in the Rift Valley. During the Congress, there will be an excursion to the Olorgesailie prehistoric site, which is being developed as a 'museum on the spot' to illustrate the evolution of the Acheulean culture. It is hoped to obtain special air-travel facilities for delegates to the Congress. All correspondence relating to the Congress should be addressed to Dr. L. S. B. Leakey, Organising Secretary, P.O. Box 658, Nairobi, Kenya.

Science and Art of Medicine

THE appointment of Sir Lionel Whitby to the regius chair of physic at Cambridge marks, as Sir Lionel himself says in his inaugural lecture ("The Science and Art of Medicine." Cambridge University Press, 1946. 1*s.* 6*d.* net), a departure from the traditions of this ancient office, which was founded in 1540. It is, Sir Lionel says, the first time that the chair has been held by a man who is primarily interested in the scientific rather than the clinical aspects of medicine. This may well be "an instinctive recognition of the importance of the scientific aspects of medicine, not forgetting that science is not all factual and itself contains much art". Medicine, too, he says later on, is both a science and an art. It will, however, never be an exact science, because every person who is ill must be approached differently. "This, the frequently ridiculed bedside manner . . . is an art which is inborn and not acquired." The science of medicine is nevertheless necessary; and one of the attractions of the profession is the personal and individual character of its practice, which constitutes one of the strongest objections to its nationalization and standardization. To-day, we "do not tend" to produce physicians as skilled and shrewd in diagnosis as those earlier workers who had to rely entirely on their personal observation; and the modern student, with so many scientific checks at his command, will do well to imitate his forbears more closely by "carefully orientating his cases before demanding wholesale laboratory work".

Before the beginning of this century, the medical practitioner was skilful in alleviating symptoms, but knew little or nothing about the causes of disease. From 1890 onwards the treatment of disease in relation to its cause rather than the treatment of its symptoms began to be developed. The beginning was made in immunology with diphtheria antitoxin. Sir Lionel then reviews briefly the immunological work of Ehrlich and his later search for specific remedies which would kill infecting organisms without harming the tissues of the body in which they cause disease. Examples follow of the use of art and imagination in modern chemotherapeutic discovery, with a timely warning against the unbridled use of the sulphonamides. There are no facts in this lecture which will not be familiar to those who have followed recent chemotherapeutic work; but the use which the author makes of the facts which he gives is both charming and remarkable.

Biologia Generalis

Biologia Generalis was founded in 1925 and published in Vienna and New York. Its aim was to provide a place for the publication of papers on general biology in the wide sense, rather than those that fall strictly within the field of either botany or zoology. It included border-line topics like aspects of physical or bio-chemistry that have application to biology or medicine, viruses, genetics, general cytology, the history and philosophy of biology and various other subjects. Messrs. Springer, of Vienna, are now resuming publication of the journal under the editorship of Prof. Ludwig von Bertalanffy. The editor points out that the War very profoundly affected the exchange of scientific knowledge and ideas, and that the biologists of Central Europe in particular have been practically isolated while it lasted. *Biologia Generalis* is the first biological journal to be issued in Austria since the period of reconstruction, and the editor appeals to his colleagues of the outside world for their help and support in re-establishing the international co-operation in biology that existed previously. Articles will be accepted for publication in English, French, German and Italian; the editor's address is Wien 111/40 Weissgärberlände 52.

British Glaciological Society

IN 1936 the Association for the Study of Snow and Ice was formed, the primary object of which was "to encourage research on, and stimulate interest in, the practical and scientific problems of snow and ice". Since then, the Association has broadened its activities. For example, it is the responsible body for nominating members of the British group of the International Commission of Snow and Glaciers, which is one of the commissions of the International Association of Hydrology in the International Union of Geodesy and Geophysics; and it is resuming its annual survey of snowfall in the British Isles. A change in name has now been decided upon, and the Association will be known in future as the British

Glaciological Society. Meetings are held at about three-monthly intervals in London, Cambridge and other places, and the papers with their discussions are printed and circulated in the Society's journal, which among other features contains a useful glaciological bibliography. Membership of the Society is open to all who have scientific, practical or general interest in any aspect of snow and ice study, and is by nomination. Further particulars may be obtained from the Assistant Secretary, British Glaciological Society, *temporary address*, c/o Royal Geographical Society, Kensington Gore, London, S.W.7.

Scientific Background in China

RECENT reports of the British Council, in describing the work of its Cultural Scientific Office in Chungking, have given some account of the position of science in China, and still more factual accounts have been given by Dr. J. Needham in *Nature* (**157**, 175; 1946, and **156**, 496; 1945). In "Chinese Science" (London: Pilot Press, Ltd., pp. 80), Dr. Needham presents the background and setting in which scientific work is carried out in China, and the vivid contrast of old and new. There is little here to indicate research actually in progress in China or the results so far achieved by Chinese workers; there is much to indicate how important will be the future contribution from workers imbued with such resourcefulness and determination to overcome the handicaps under which they have been compelled to work. Few who read this admirably illustrated little volume can doubt that under the organisation already established, and which Dr. Needham outlines in his preface, Chinese research workers will speedily be making unique contributions in fields of their own, and that urgent as may be China's needs for equipment and supplies, even now the traffic will not be only one way. Four profusely illustrated chapters describe the position of scientific and educational institutions in Szechuan, in the north-west, the south-east and the south-west, and if the emphasis is on the workers and conditions rather than on the work being done, that may well enhance the appeal to the general reader to whom, rather than to the man of science, it is obviously addressed.

Mechanism of Orogenesis and Volcanic Activity

IN a pamphlet dealing with "The West Indies and the Mountain Uplift Problem" (privately printed by B. T. Ord, Ltd., West Hartlepool, 1945, pp. 25+6 figs.), Dr. C. T. Trechmann presents a short account of the geological structure and history of the West Indies, largely based on his own observations; and having found there a puzzling assemblage of phenomena, such as causes difficulty to geologists from time to time, he expresses his disbelief in the various hypotheses now on trial and offers alternative suggestions. Dr. Trechmann's attempt to account for orogenesis and vulcanism, with special reference to the West Indies, involves the following fallacious or demonstrably untenable ideas: (*a*) that ocean water at considerable depth penetrating unconsolidated or fragmentated conglomerates may induce metasomatism and generate heat by exothermic reactions; (*b*) that the floor of the Bartlett Trough may be lowered and that gaseous or magmatic and plastic material may be forced inwards and upwards beneath Jamaica and Cuba by the pressure due to four miles of sea water; (*c*) that the upward tidal pull on emergent land may be cumulative, so inducing a landward flow of sub-crustal magmatizing gases or liquids and thereby still further raising the land and deepening the adjacent sea floor. If Dr. Trechmann were able to visualize the kind of earth that would have resulted from the operation of the above alleged processes, he would find it strikingly at variance with the real earth with which geologists are concerned.

Analysis of High-Purity Zinc and Zinc Alloys

PHYSICAL methods of analysis, such as by the use of the polarograph or the spectrograph, are particularly suited to the determination of minute quantities of impurities in zinc and its alloys. A panel was appointed in 1941 by the Non-ferrous Industry Committee of the British Standards Institution to consider recommended methods for the polarographic and spectrographic analysis of high purity zinc and zinc alloys for die casting. The panel found in its review of earlier work that, though the spectrograph was used in certain laboratories, neither the details nor the precision of the technique was sufficiently defined to justify the immediate recommendation of a spectrographic method; the use of the polarograph was observed to be even less developed. The panel therefore planned, and had carried out by a number of interested organisations, a considerable amount of experimental work. An account of these investigations has been published under the title "Polarographic and Spectrographic Analysis of High Purity Zinc and Zinc Alloys for Die Casting" (H.M. Stationery Office, 1945). Based on this work, recommended methods have been prepared in order to enable comparative information to be collected. The recommendations of the panel, "Recommended Methods for Polarographic and Spectrographic Analysis of High Purity Zinc and Zinc Alloys for Die Casting" (British Standard 1225; 1945. Pp. 36. 2*s*. net), are intended to be a guide and not a rigorously binding specification. The methods are effective, but, as the fields of analytical chemistry in which they lie are rapidly expanding, the Committee does not wish to impede development by strict rules. It is intended, therefore, to review the position at an early date in the light of further experience obtained by the use of these methods.

The National Museum of Wales

THE progressive activity of all departments of the National Museum of Wales is a striking feature of the report for the year 1944–45. Most of the material removed from the public exhibition galleries has now been restored and the reorganisation of certain parts of the collections is near completion. In accordance with the strong educational policy of the Museum, departmental lectures, gallery talks, demonstrations and special exhibitions have been provided throughout the year. The value of these is amply proved by the large attendance of students, teachers, classes of school-children and groups of Service men and women. Of the several public lectures given outside the Museum, mention may be made of a series of three given by the Keeper of the Department of Folk Culture and Industries to teachers at a Ministry of Education course held at Caerleon.

It is of further interest that the director of the Museum, after consultation with the Welsh Department of the Ministry of Education, prepared on behalf of the Council and at the request of the permanent secretary, a memorandum setting out the Museum's suggestions for a schools service. This document comprised: (1) a record and assessment

of the Museum's past and present achievement in this field of its work (this part being intended for circulation to local education authorities and other interested bodies), and (2) a full description of (*a*) the requirements envisaged for a comprehensive service, and (*b*) the minimum requirements for an initial trial period of five years. A full list of the material acquired by the various departments during the year is to be found in Appendixes I–III, and Appendix IV lists publications by members of the staff. The usual list of the publications of the National Museum of Wales appears in Appendix VII.

Agricultural Museums ?

THE Agricultural History Society (Washington, D.C.) was founded in 1919 "to stimulate interest in, to promote the study of, and to facilitate research and publication on the history of agriculture". In Vol. 19 (July 1945) of the Society's quarterly journal *Agricultural History*, Herbert A. Kellar has contributed a paper on "Living Agricultural Museums", in which he shows how much the museum may do to promote the aims of the Society. Notable progress has been made in the museum idea since 1920, particularly as regards the importance attached to accuracy, the introduction of motion into the exhibits and the recognition of the necessity for an appropriate setting for the objects. As an illustration of the latter, he describes a recreated village typical of rather more than a century ago that has been set up near Springfield, Illinois, where no modern effects are allowed to detract from the reality of the scene. His conception of a national agricultural museum is particularly ambitious, as he envisages an institution where not only the historical and social aspects of agriculture should be portrayed by means of exhibits, but which should also act as headquarters of important national farm organisations, and serve as a centre for educational activities, with special library and theatre attached. Branch museums specializing in matters of local interest, such as the Farmers Museum sponsored by the New York Historical Association at Cooperstown, are suggested as extensions of the central unit. Here exhibits of both indoor and outdoor forms of agricultural operations might well be compared with those of earlier periods, illustrating, for example, the evolution of machinery, transportation, milling, tanning or other processes.

Electricity Supply Legislation in Britain

A PAPER read in London on February 7 by W. Fennell before the Institution of Electrical Engineers examines a number of the legal provisions regulating the relations and rights as between undertakers and consumers of electricity. Suggestions are made as to revision which is necessary to promote the further expansion of the industry and the maintenance of good relations with consumers. Among other matters, the author deals with the existing complicated provisions in the Electric Lighting (Clauses) Act of 1899, which intending consumers can follow in any application for a supply of electricity; with service connexions; with charges for supply; with the authorization of inspection and inquiry; and with meters.

Fate of German Ornithologists

MRS. MARGARET NICE, the well-known American ornithologist, has heard from Dr. Stresemann that Dr. Konrad Lorenz, one of the pioneers in the study of behaviour, notably in birds, whose probable death was reported in *Nature* of November 10, 1945, p. 578, is alive. He is a prisoner in Russian hands, unwounded, and employed as a camp physician. The same letter also contains news of other German ornithologists: Dr. Steinfatt is in Denmark, but will shortly be returning to Germany; Dr. Meise is alive, but still in Russian hands.

Advanced Lectures on Special Librarianship

THE Association of Special Libraries and Information Bureaux hopes to organise a course of advanced lectures on special librarianship during the period May to July 1946, to be given at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1. It is proposed to hold the lectures in pairs on a Friday evening and the following Saturday morning with a fortnight's interval between each pair. No examination will be held. The subjects to be covered will include classification, bibliography, special library routine, recording and filing of research material, abstracting, the use of statistics, documentary reproduction, editorial work and the compilation of technical information bulletins. The fee for the whole course (twelve lectures) will be £5 5*s*., but applicants may, if they wish, attend six lectures only at a fee of £2 15*s*. Lecture programmes and application forms can be obtained from the General Secretary, ASLIB, 52 Bloomsbury Street, W.C.1.

Announcements

ON the joint recommendation of the presidents of the Royal Society and the Institution of Civil Engineers, the Council of the Institution of Civil Engineers has awarded the James Alfred Ewing Medal for 1945 to Prof. R. V. Southwell, rector of Imperial College of Science and Technology, London, for specially meritorious contributions to the science of engineering in the field of research.

THE REV. D. O'CONNELL, *S.J.*, of Riverview College Observatory, New South Wales, states in the course of a letter that Dr. H. P. Berlage, jun., of the Royal Observatory, Batavia, who is well known for his work on the origin of the solar system, is now in Bandoeng after spending three and a half years in a Japanese internment camp in Java.

A SYMPOSIUM arranged by the Road and Building Materials Group of the Society of Chemical Industry will be held on May 8 at the Royal Institution to discuss "Shrinkage and Cracking of Cementive Materials". This symposium has been organised in conjunction with the Ministry of Works so that men of science working on topics connected with urgent problems in the building campaign will have the opportunity of making their contribution. There will be two sessions: 10.30 a.m. to 12.30 p.m. and 2.30 p.m. to 5 p.m.

THE Scientific Film Association (34 Soho Square, London, W.1) has voluntarily undertaken the task of preparing a comprehensive and up-to-date catalogue of the films of scientific interest which are available for general distribution in Great Britain. This work is being published by the Association of Special Libraries and Information Bureaux and will be ready this month. It contains details of 600 films, many of which have been appraised and the majority graded. The catalogue is to be sold at five shillings per copy to non-members of the Scientific Film Association. It is proposed to issue supplements from time to time to keep the catalogue up to date.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Chemical Taxonomy

THE differences between species of animals and of plants are ultimately chemical, and Ford[1] has shown in butterflies that classification based upon morphology corresponds with chemical differences in pigments. The distinction between two species within a genus must be due, in part at least, to differences between their proteins. Such differences cannot be shown by ordinary chemical methods, but in the case of one protein, namely, haemoglobin, differences have lately been found by spectroscopic means between several species of the crustacean genus *Daphnia*[2]. In this genus it has long been a matter of discussion as to whether the species *D. obtusa* Kurz is really worthy of specific rank or is merely a variety of *D. pulex* (De Geer). Scourfield has, however, recently discovered a new, clear-cut morphological distinction between the two forms which confirms the specific rank of *D. obtusa*[3]. In these circumstances it is particularly interesting to find that their haemoglobins also differ[2]. Another such instance of spectroscopic evidence in a case of doubtful specificity can now be reported.

Besides the common British species of the marine polychæte genus *Sabella*, namely, *S. pavonina* Savigny, there is found on our coasts an uncommon form known as *S. pavonina* var. *bicoronata* Hornell. Unlike the typical *S. pavonina*, this variety has a crown with its two sides unequal in size, although less unequal than in the case of *Spirographis spallanzanii* Viviani. The variety *bicoronata* thus appears at first to be intermediate between *Sabella pavonina* and *Spirographis spallanzanii*. The status of the three forms has now been re-examined by Ewer[4], who concludes that *Spirographis* is so close morphologically to *Sabella* that it does not merit generic rank. He therefore abolishes the former genus. Ewer confirms the status of *bicoronata* as a variety of *Sabella pavonina*, not promoting it to a species intermediate between *S. pavonina* and *S. spallanzanii*; for this decision he makes use both of external and blood vascular characters.

Twenty years ago, I compared the chlorocruorin absorption spectra of *Sabella pavonina* and *S. spallanzanii*, using the Hartridge reversion spectroscope, and found them to differ both in the wave-length of the axis of the α-band of their oxychlorocruorins and in their span (that is, the difference between the α-band in the oxy- and carboxy-compounds)[5]. It now becomes of interest to obtain the corresponding values for the variety *bicoronata*, in order to see whether they coincide with the values for *S. pavonina* or are intermediate between those for the two *Sabella* species. I have therefore repeated my measurements for *S. pavonina* and have obtained new data for var. *bicoronata*. The same spectroscopic precautions were taken as those lately described[6], and in addition another most important routine procedure, which should then have been mentioned, was always followed. For unknown subjective reasons, there are days when the wave-length values obtained for known absorption bands are higher, or on other days lower, than usual, by one or several Angström units. This unavoidable error can be eliminated by measuring the α-band of the observer's own oxyhæmoglobin, using the standard dilution of clear laked blood, with standard illumination and slit opening. This measurement is made at the beginning and again at the end of each day's investigation, and the excess or deficit from the average value for oxyhæmoglobin (this average being known from numerous previous measurements) is added to or subtracted from the values found that day for the unknown substances.

I find that in var. *bicoronata* the α-band of oxychlorocruorin has a wave-length 8 A. shorter than in *S. pavonina*, the value of which is 6061 A. Previously, I had found the value for *S. spallanzanii* to be 11 A. shorter than for *S. pavonina*, so that in this respect var. *bicoronata* is nearer *S. spallanzanii* than *S. pavonina*. On the other hand, the spans of var. *bicoronata* and *S. pavonina* turn out to be the same as one another, whereas the spans of *S. spallanzanii* and *S. pavonina* had been found[6] to differ by 16 A. The spectroscopic data show, then, that as regards one protein at least, var. *bicoronata* differs from the typical *S. pavonina* and approaches *S. spallanzanii*.

H. MUNRO FOX.

Bedford College,
University of London.
Feb. 5.

[1] Ford, E. B., *Proc. Roy. Ent. Soc. Lond.*, **16**, 65 (1941); **17**, 87 (1942); **19**, 92 (1944); *Trans. Roy. Ent. Soc. Lond.*, **94**, 201 (1944).
[2] Fox, H. M., *Nature*, **156**, 475 (1945).
[3] Scourfield, D. J., *Ann. Mag. Nat. Hist.*, **9**, 202 (1942).
[4] Ewer, D. W., *J. Mar. Biol. Assoc. U.K.*, in the press.
[5] Fox, H. M., *Proc. Roy. Soc.*, B, **99**, 199 (1926).
[6] Fox, H. M., *Nature*, **156**, 18 (1945).

An Antibiotic from *Spiræa aruncus* L.

FOLLOWING the observation[1] that a watery extract of leaves and flowers of *Spiræa aruncus* L. possesses antibacterial properties, the active substance has now been isolated from the plant in crystalline form. It has, however, very low activity, preventing the growth of *Staph. aureus*, *B. proteus* and *B. coli* in a dilution of only 1 in 4,000, and having no effect on *Ps. pyocyanea* at 1 in 2,000. In view of its low activity, the substance has not been investigated in detail, but it is perhaps worth putting on record the following results.

An aqueous extract was prepared by grinding the fresh leaves and flowers with sand and distilled water and pressing out the fluid. The latter was adjusted to pH 3, boiled and centrifuged. The supernatant liquid was extracted three times with equal volumes of ether, which were pooled, concentrated by distillation and passed through a column of acid-washed alumina (final pH about 5·0). The antibiotic was situated in a band in the middle of the column, from which it was eluted with phosphate buffer *p*H 6·5, and afterwards extracted into ether. On evaporation of this ethereal extract there remained an orange-coloured oil. Extraction of the oil with hot benzene gave a solution from which the active substance separated in crystalline form on cooling. It was recrystallized by the addition of benzene to its solution in chloroform, and formed fine colourless prisms, m.p. 79–80° C. $[\alpha]_D^{20}$ (in water) + 55·8°.

The results of elementary analysis and molecular weight determination (Barger method) indicated that the molecular formula of this substance was $C_{16}H_{14}O_4$. The molecule contained 0·8 C-methyl groups according to the Kuhn–Roth determination. O-methyl was absent.

In the presence of palladium charcoal catalyst, the substance absorbed six atoms of hydrogen. In solution in a mixture of carbon tetrachloride and chloroform there was a rapid addition of two atoms of bromine.

A solution of the substance in pyridine gave a weak reddish-brown colour with sodium nitroprusside[2]. It did not reduce Tollen's reagent at room temperature, but produced an immediate heavy precipitate of silver from a solution of ammoniacal silver nitrate containing caustic soda[3].

The active substance was neutral and showed no ketonic properties. On treatment with cold alkali, however, by which its antibacterial activity was destroyed, one acidic group appeared; at the same time, ketonic properties became detectable, for Brady's reagent then precipitated an acidic 2·4 dinitrophenylhydrazone from the acidified solution.

Some of the properties of this antibiotic suggest that an α-β unsaturated lactone ring may be present in its molecule.

E. P. ABRAHAM.
N. G. HEATLEY.
R. ROLT.
E. M. OSBORN.

Sir William Dunn School of Pathology,
University of Oxford. Feb. 19.

[1] Osborn, *Brit. J. Exp. Path.*, **24**, 227 (1943).
[2] Jacobs and Hoffmann, *J. Biol. Chem.*, **67**, 336 (1926).
[3] Thiele, *Ann.*, **319**, 144 (1901).

A Light-Sensitive Enzyme in Cow's Milk

WHILE during the natural traffic between dam and suckling there is no exposure of the milk to daylight, under dairy industrial conditions there is often very considerable exposure. The effect of daylight or sunlight on milk has not received much experimental attention, though Kon and Watson[1] showed in 1936 that light brought about the oxidation of vitamin C in milk.

In experiments published in 1938[2], it was shown that an enzyme which hydrolyses tributyrin was present in all samples of fresh cow's milk examined. The determination of the lipase activity of milk samples was usually carried out immediately they were received from the cow-house, particularly since it was observed that, if they were kept (in glass bottles) on the laboratory bench for a few hours, variable losses of up to 20 per cent of the original lipase activity might be incurred. Whereas these losses showed no clear correlation with temperature, they could usually be avoided by storing the milk in the ice chest. In experiments done conjointly with the late Dr. E. C. V. Mattick just before the War, it appeared highly likely that this effect was due to the sensitivity of the lipase to visible light.

This investigation had to be put on one side owing to war urgencies, but it has been taken up again recently, and there is no doubt that the lipase (tributyrinase) of cow's milk is quite sensitive to sunlight. Exposure of fresh milk in glass vessels (depth of milk approximately 1 cm.) to bright summer sunshine for 10 minutes destroys 40 per cent of the enzyme (milk at a temperature under 5° C.), while exposure for 30 min. achieves about 80 per cent destruction. Thirty minutes exposure on the laboratory window-sill, but out of direct sunlight, may cause 30 per cent destruction of the lipase.

A source of ultra-violet light will also readily bring about the destruction of the enzyme in milk. Half an hour exposure to an 800-watt (220-volt) quartz mercury vapour lamp at a distance of 15 cm. destroys three quarters of the lipolytic power of the milk. The interposition of a piece of half-inch plate-glass affords little protection; it would appear, therefore, that here again the active wavelengths are those in the visible spectrum. This is supported by preliminary experiments in which milk in a number of glass vessels of the same size but covered with 'Cellophane' of different colours was exposed to sunlight. The destructive power of the transmitted light increased in the order: red (low activity), yellow, green, blue, the blue light being only a little less active than the full sunlight (through glass). Sunlight falling directly on the milk was rather more active in destroying the lipase than sunlight through glass.

If oxygen is removed as thoroughly as possible from milk by boiling it under reduced pressure or by washing oxygen out with a stream of pure nitrogen, the destructive effect of subsequent exposure of the milk to sunlight is greatly diminished. The addition of 0·1 per cent of sodium cyanide also protects (though not completely) the lipase from destruction by direct sunlight. On the other hand, the rate of photo-destruction of the enzyme may be markedly increased by adding 100 μgm. of riboflavin to 100 ml. of the milk (cow's milk normally contains some 150 μgm. of riboflavin per 100 ml.). This recalls the similar sensitizing effect of riboflavin on the photo-oxidation of vitamin C[3]. If milk is exposed for a few minutes to sunlight and then kept in the dark, the destruction of lipase continues rapidly at first but ceases in about three hours. Nevertheless, fresh milk, added to milk in which the lipase has been completely inactivated by light, loses none of its activity even on standing for several hours. The investigation is being extended.

H. D. KAY.

National Institute for Research in Dairying,
Shinfield, Reading. Jan. 8.

[1] Kon, S. K., and Watson, M. B., *Biochem. J.*, **30**, 2273 (1936).
[2] Mattick, E. C. V., and Kay, H. D., *J. Dairy Res.*, **9**, 58 (1938).
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Pyruvic Acid in the Juice of Onion (*Allium Cepa*)

SOME years ago, during a search for the presence of reducing substances in plants, I obtained a positive Simon and Piaux[1] (nitroprusside) test for pyruvic acid in onion juice. Owing to the intensity of the reaction it seemed worth while to estimate and identify pyruvic acid.

Several mature onions (*var.* Suttons *A*1) which had been pulled up and stored for one month were minced, and then squeezed through linen. 40 ml. of the juice were immediately made 5 per cent with respect to trichloroacetic acid. The precipitate was centrifuged off and well washed with 5 per cent trichloroacetic acid. The supernatant fluid and washings were then filtered. Pyruvic acid was estimated in the filtrate by weighing the 2 : 4-dinitrophenylhydrazine derivative, using the method of Simon and Neuberg[2]. The pyruvic 2 : 4-dinitrophenylhydrazone weighed 0·1260 gm., corresponding to 0·1034 gm. of pyruvic acid per 100 ml. of onion juice.

The pyruvic 2 : 4 dinitrophenylhydrazone melted at 209° uncorr., gave a deep red colour with 6 per cent alcoholic potash, and a lemon-yellow colour with 85 per cent sulphuric acid. Once recrystallized from ethyl acetate, it melted at 213° uncorr. (found (Weller): C, 40·00; H, 2·89; N, 20·80 per cent. $C_9H_8O_8N_4$ requires C, 40·30; H, 3·00; N, 20·89 per cent).

Judging from the nitroprusside test, there is no pyruvic acid in the intact onion. It is very rapidly formed from a precursor, or precursors, when the onion tissue is wounded (that is, minced or ground up in a mortar). This was demonstrated by the following experiment, which was repeated on individual onions several times with the same result.

An onion was weighed and cut in half, one half was quickly placed in a mortar under twice its weight by volume of 10 per cent trichloroacetic acid, and the other half under the same volume of water. Both halves were then cut up under the acid and water respectively, ground up with a little sand, and centrifuged. The same volume of acid was then added to the supernatant fluid from the water extract, and both made up to the same volume with water. Both were then saturated with ammonium sulphate and filtered. The trichloroacetic acid extract of half the onion gave a negative test for pyruvic acid, while the water extract gave a very strong positive test.

Cutting and grinding the onions up under 0·5 *M* sodium fluoride does not prevent the formation of pyruvic acid.

E. J. MORGAN.

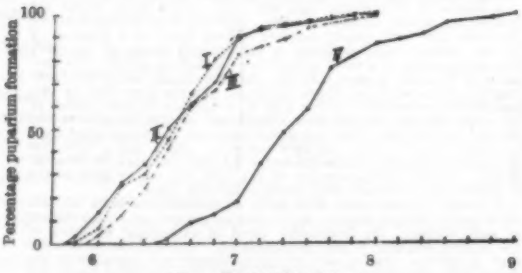
Biochemical Laboratory,
Cambridge.
Jan. 9.

[1] Simon, L. J., and Piaux, L., *Bull. Soc. Chim. Biol.*, **6**, 477 (1924).
[2] Simon, E., and Neuberg, C., *Biochem. Z.*, **232**, 479 (1931).

Inhibitory Effects of the Corpora Cardiaca and of the Corpus Allatum in *Drosophila*

THE function of the corpora cardiaca in Diptera is, at present, obscure. According to unpublished data of M. Thomson (cit. by E. Thomsen[1]), an extract of the corpus cardiacum of the blowfly (*Calliphora*), when injected into blinded shrimps (*Leander*) with maximally expanded chromatophores causes a strong contraction of the red and black pigment. Whether the corpus cardiacum acts similarly on the pigment cells in Diptera is unknown. Two other effects of the corpora cardiaca, obtained in transplantation experiments on *Drosophila hydei*, will be reported here.

One of the effects of implanted corpora cardiaca consists of an inhibition of the normal colouring of the puparium, the latter only attaining a brown colour instead of the normal red colour characteristic for *Drosophila hydei*.



PERCENTAGE DISTRIBUTION OF TIME OF PUPARIUM FORMATION.
I = control series. Mean = 6·62 ± 0·04 days (*n* = 119).
II = fat body series. Mean = 6·62 ± 0·06 days (*n* = 61).
III = corpora allata series. Mean = 6·75 ± 0·06 days (*n* = 58).
IV = corpora cardiaca series. Mean = 7·51 ± 0·07 days (*n* = 56).

The second effect is a delay in puparium formation, as shown in the accompanying figure. Curves I–IV represent the percentage distribution of puparium formation in four different experimental series. Curve I, serving as control, shows the time of puparium formation after injection of Ringer solution, while curve IV was obtained after implantation of 2–5 pairs of corpora cardiaca taken from 4-days old adult females. (For all experiments, larvæ aged 2 days 21 hours were used as hosts. As the corpora cardiaca are fused with the ganglion hypocerebrale, both tissues were transplanted together.) A comparison of the two curves shows that about 40 per cent of the controls had formed puparia before the first larva with implanted corpora cardiaca started pupation, and that 90 per cent of the controls had pupated at a time when only 20 per cent of the corpora cardiaca series had done so. The delay in pupation caused by the implantation of corpora cardiaca is also obvious from the means, the mean for the control series being 6·62 ± 0·04 days, that for the corpora cardiaca series 7·51 ± 0·05 days. The possibility that the delay in puparium formation was a non-specific effect of any adult tissue was excluded by testing the action of two other organs from adult females. Pupation occurred at the normal time when either the fat body (curve II) or the corpus allatum (curve III) were implanted into the hosts.

The actions of the corpora cardiaca on the colouring process of the puparium and on the time of puparium formation are independent from each other. This is shown by the fact that the corpora cardiaca of adult females, when implanted into older larvæ, exert no delaying action on puparium formation, while their inhibition of the colouring process remains unchanged.

The fact that no action whatsoever on the time of pupation was observed after implantation of corpora allata (curve III) is interesting from two more aspects. First, the absence of any accelerating effect on puparium formation agrees with the view expressed by Scharrer and Hadorn[2] and Vogt[3], according to which the pupation hormone originates only from large cells which form the lateral part of the larval ring-gland and which do not belong to the corpus allatum. Secondly, the absence of any delay of puparium formation in *Drosophila* differs from the inhibition of metamorphosis produced by the corpora allata in other insects. In these, either supernumerary larval moults were observed or moults intermediate between a larval and a pupal (or imaginal) moult. In certain instances, however, the inhibitory action was restricted to parts of the skin in the immediate neighbourhood of the implanted corpora allata[4]. In the present experiments on *Drosophila*, defects in the imaginal skin of the abdomen (the injections were made into the larval body cavity at the level of the abdominal segments) were observed in 52 per cent (*n* = 54) of the hatched flies of the corpora allata series. Similar defects, usually of smaller size, were obtained in 5 per cent (*n* = 119) of the controls, in 2 per cent (*n* = 60) of the fat-body series and in 0 per cent (*n* = 56) of the corpora cardiaca series. The defects were characterized by the absence of pigment, hairs and a typical cuticle, and extended occasionally over several segments. The statistically significant difference between the corpora allata experiment and the other three series establishes an inhibitory effect of implanted corpora allata on the development of the imaginal characters in the abdominal skin at the site of implantation. (In other insects, the inhibited areas show larval characters instead of imaginal ones. Imaginal characters might be expected when dealing with inhibition of the pupal moults in Diptera but not in the present instance of an inhibition of the imaginal moult, since the imaginal skin of *Diptera* consists of special 'imaginal' cells which never form larval structures during development.) If we may consider these actions to be analogous to the restrictive effect of implanted corpora allata occasionally observed in other insects, the inhibitory effect of the corpus allatum in Diptera would not differ in principle from that in other insects. Another indication of an inhibitory action of the corpus allatum in *Drosophila* was previously obtained in a study of the imaginal differentiation of the eye disks[5].

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Lack of Optomotor Reactions in a White-eyed Mutant of *Culex molestus*

THE white-eyed mutant of *Culex molestus*[1], recently detected in the Department of Entomology in the London School of Hygiene and Tropical Medicine, made it possible to repeat experiments performed on normal and white-eyed individuals of *Drosophila melanogaster*, *D. pseudoobscura*[2] and (unpublished) *D. subobscura*: in these experiments it was shown that the pigments normally separating the individual ommatidia in the compound eye are necessary for the perception of moving contours and that white-eyed individuals, regardless of genetical constitution, do not show optomotor reactions.

Wild-type *Culex molestus* shows optomotor reactions similar to those described for *Aedes aegypti*[3], and the methods developed for this species can be applied to test the former's behaviour. However, the simpler cylinder arrangement described for *Drosophila*[2] can be equally used for the mosquito, the only modification being a different glass container, namely, a flat-bottom vial 1½ in. wide and 4 in. long in which the mosquitoes can fly. When the striped cylinder is set in motion, the mosquitoes become agitated, and after a few seconds typical optomotor reactions are observed. The best reactions, namely, a turning of the flying mosquito following the rotation of the cylinder, were observed at a speed of about two rotations per second using a pattern of five black stripes interspersed with five equally wide white stripes (each 36° wide). Postures similar to those described for sitting flies[4] could also be observed in wild-type mosquitoes, when sitting on the bottom, ceiling or the walls of the vial. None of these reactions was ever observed in the white-eyed mutants. The insects did not become agitated nor did they circle or bend, when the striped pattern was set in motion; in fact they did not show any sign of movement perception. It should perhaps be mentioned that they did show phototaxis, as the normal mosquitoes do, but in contrast to the white-eyed *Drosophila*, they mostly flew away from strong light.

Thus the lack of optomotor reaction in white-eyed mosquitoes, confirms the conclusion, drawn from the study of the behaviour of white-eyed *Drosophila* mutants, that the pigments isolating the rhabdomeres in an apposition eye are necessary for the perception of contours and visual movement. A description of the behaviour of white-eyed drones[5] further strengthens this conclusion. As reported by Gilchrist and Haldane[1], white-eyed *Culex molestus* mate and breed successfully. Therefore the conclusion can be drawn—as it can for *Drosophila melanogaster* and *D. pseudoobscura*—that at least under laboratory conditions mating in this mosquito does not depend on the partners seeing each other.

In *D. subobscura* this seems necessary[6], as this species does not breed in the dark and as its white-eyed mutant cannot be bred at all in the homozygous condition.

I want to thank Miss B. M. Gilchrist, of the Department of Entomology, the London School of Hygiene and Tropical Medicine, for allowing me to use her material.

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Sweat Glands

The following observations on the sweat glands in animal skins seem worth recording.

Cattle skin. In the course of examining a number of ox-hide sections several years ago it was noted that the duct of the sweat gland at some point came to lie between the *arrector pili* muscle and the sebaceous gland. This has recently been confirmed in calf-skin (shown in Fig. 1,

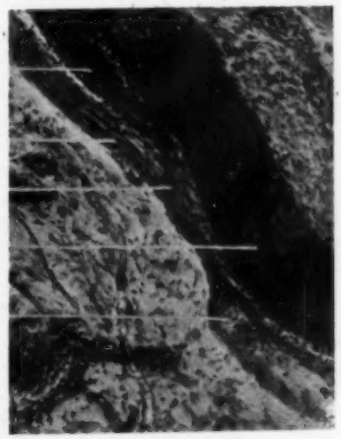

Fig. 1. (× *c.* 110.)

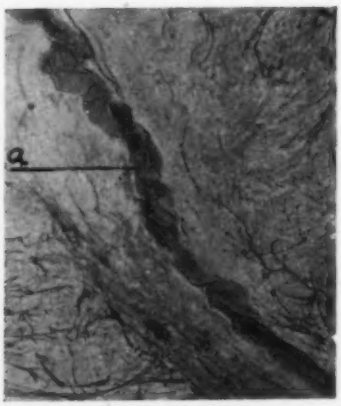

Fig. 2. (× *c.* 64.)

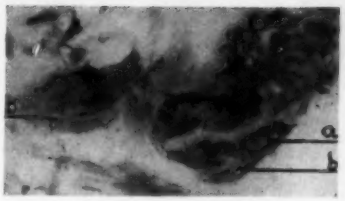

Fig. 3. (× *c.* 420.)

from a frozen section stained with Heidenhain's hæmatoxylin) in which the actual cross-over of the muscle and duct was observed. The gland (*a*) narrows into the duct below the insertion of the muscle into the hair follicle (*b*) and the duct immediately traverses (at (*c*)) the base of the muscle and lies for a short distance between it (*d*) and the sebaceous gland (*e*). It follows that conditions, such as cold, which stimulate the contraction of the muscle, with the consequent action of expelling sebum from the sebaceous gland, will also bring about constriction of the duct of the sweat gland, so preventing excretion from the gland.

Dog skin. Sweat glands were observed in the butt, shoulder and belly regions of two mongrel dog skins, which also contained very large amounts of fat among the corium fibres. The coiled duct (*a*) is shown in Fig. 2 of a frozen section stained with Weigert's elastin stain. Some details of the gland are shown in Fig. 3 from a paraffin section stained with toluidine blue; *a* indicates a cubical epithelial cell and *b* smooth muscle cells.

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Reaction of Nucleic Acid to Aceto-carmine

The non-stainability of many plant and animal chromosomes toward the Feulgen reagent[1] after prolonged hydrolysis with *N* hydrochloric acid at 60° C. has recently also been demonstrated in the salivary gland chromosomes of *Chironomus*[2]. Since the Feulgen reaction and aceto-carmine staining are both used for the demonstration of nucleic acid within the chromosome, it would be of interest to know whether acid hydrolysis will also cause the chromosomes to behave negatively toward the aceto-carmine dye. From the experiments thus conducted it was found that in the early period of hydrolysis (generally after 3–5 min.) the salivary gland chromosomes stained with aceto-carmine more distinctly than those unhydrolysed controls, due probably to the removal of other stainable components surrounding the chromosomes. This strong stainability was not changed within fifteen minutes of hydrolysis. Now, if the duration of hydrolysis exceeded this upper limit, a weaker staining capacity of these chromosomes toward the aceto-carmine dye would result; and finally they might reach a stage practically unstainable if hydrolysis was allowed to continue for 25–30 minutes. This means that the staining reaction of salivary gland chromosomes toward the aceto-carmine dye after hydrochloric acid hydrolysis was entirely parallel to that toward Feulgen reagent.

On the basis of these preliminary findings, the staining reaction of nucleic acid to aceto-carmine has been studied by experiments *in vitro*. A saturated solution of yeast nucleic acid was prepared, and into each of two test tubes 4 c.c. of this solution was poured. To the first tube 1 c.c. aceto-carmine dye was added; a red precipitate formed almost instantaneously. To the other 1 c.c. 45 per cent acetic acid was added (to obtain the analogous acid strength of aceto-carmine dye); no precipitation was observed. The precipitate produced by mixing aceto-carmine and nucleic acid solution was insoluble in water and acetic acid but readily soluble in mineral acids such as hydrochloric, sulphuric and nitric, giving a clear red solution.

The next point which we investigated was the reaction between some proteins and aceto-carmine. Three aqueous protein solutions: 1 per cent gelatine, egg albumin diluted (1 : 8) and saturated casein solution, were used for this purpose. 4 c.c. of each of the above three protein solutions were poured into three separate test tubes, and to each of them 1 c.c. of aceto-carmine dye was added. In the case of gelatine and egg albumin, the resulting mixture was a transparent red solution. In the case of casein, we obtained a more or less turbid one; this turbidity was not cleared up by the addition of mineral acids. The above reaction was repeated with gelatine and egg albumin solutions containing nucleic acid. 6 c.c. of the gelatine and 6 c.c. of egg albumin solutions respectively were shaken with 2 c.c. of saturated nucleic acid solution to ensure a thorough mixing. These mixtures, while turbid in the first instance, were finally all perfectly clear solutions. To 4 c.c. each of these mixtures, 1 c.c. of aceto-carmine dye was added. Turbid suspensions of fine precipitate were obtained. These precipitates, like those formed in the reaction between nucleic acid alone and aceto-carmine, were soluble in mineral acids. This indicates that the simultaneous presence of proteins, like gelatine and albumin, in a reacting mixture does not interfere with the reaction between nucleic acid and aceto-carmine dye.

The staining reaction of chromosome thymo-nucleic acid *in situ* as well as that of yeast nucleic acid *in vitro* clearly demonstrates that nucleic acid has, in general, a strong combining affinity with the dye aceto-carmine. The nature of the compound thus formed is unknown, but presumably it is combined through a salt-like linkage. The non-

stainability with this dye of salivary gland chromosomes after prolonged hydrolysis is probably also due to the removal of nucleic acid residues during hydrolysis.

Aceto-carmine smearing is a well-known cytological technique. But the differentiation of the chromosome is thereby often not so good, due to the interference of the stainable components present in cytoplasm. From our experience, it can be suggested that such a difficulty may be easily overcome through a three-minutes hydrolysis in *N* hydrochloric acid at 50–60° C., since most of the nucleic acid or its derivatives can be removed from those cellular components other than chromosomes after this mild hydrolysis.

I wish to acknowledge my indebtedness to Dr. M. Dixon for his gift of a sample of yeast nucleic acid through the Sino-British Science Co-operation Office organized by Dr. J. Needham, to whom my sincere thanks are also due.

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Abnormal Precipitation of Proteins from Antitoxic Horse Plasma in the Presence of Phenolic Compounds

Most of the work that has been carried out on the effect of phenol and similar antiseptics on antitoxic plasma has been summarized by Marrack[1] and deals largely with the destruction of the antitoxin by concentrations normally used for antiseptic purposes (0·3–0·5 per cent).

Apart from the Imray patent[2], where high concentrations of phenol were used as a bactericide, there seems to have been little work carried out with antitoxic plasma on the effect of concentrations of antiseptics higher than those normally used for asepsis.

If antitoxic horse plasma is treated with increasing concentrations of ammonium sulphate the proteins are normally precipitated in the order: fibrin, globulins and albumin. If, however, the precipitation is carried out in the presence of 2·0 per cent phenol or 1·0 per cent tricresol, the albumin is precipitated by low concentrations of ammonium sulphate, and its precipitation occurs before the globulins are precipitated. This is illustrated by the accompanying curves showing the precipitation of antitoxin and protein from antitoxic horse plasma (diphtheria) diluted with: (1) an equal volume of water; (2) an equal volume of 2·0 per cent tricresol in water.

The brown pigments normally associated with the albumin are also precipitated with it, and we can obtain, by a single precipitation with ammonium sulphate, almost colourless solutions of the globulins.

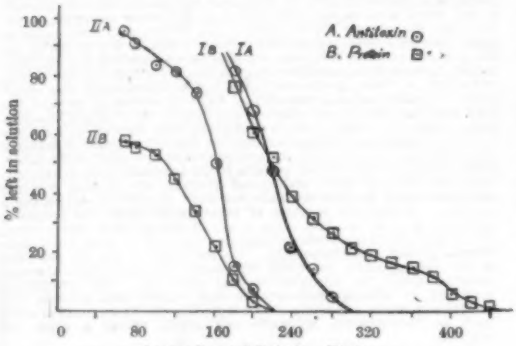

Fig. 1.

(1) (2)

Fig. 2. Electrophoretic diagrams. Descending (cathode) limb exposures.

1. Without tricresol. 2. With tricresol.

Composition	1	2
γ-globulin	28·6 per cent	35·9 per cent
β- ,,	45·9 ,,	64·1 ,,
α- ,,	21·1 ,,	—
Albumin	4·4 ,,	—

The above observations have led to an improved method for concentrating antitoxic sera, since it is possible by a single precipitation with ammonium sulphate to obtain a solution consisting almost completely of beta and gamma globulins, which have associated with them a very large proportion of the antitoxin. A further precipitation with ammonium sulphate will separate these globulins from the solution, and the resulting precipitate can be dialysed to give concentrated solutions of the antitoxic globulins. These solutions are considerably lighter in colour than those prepared by the normal ammonium sulphate concentration methods, and they also possess the valuable property of remaining clear over long periods. The yield of antitoxin is approximately the same, but the purity is very slightly greater. The above electrophoretic analysis shows the marked difference in composition of the concentrates prepared by the two methods. For this analysis I am indebted to Mr. Charlwood.

Since very much lower concentrations of ammonium sulphate are necessary in the presence of 1·0 per cent tricresol to precipitate the protein containing no antibody, this method can be used for concentrating antibacterial sera, for these antibodies tend to be associated with the lower globulin fractions. It has been found possible to apply this method successfully to sera prepared against the following organisms: influenza virus type A; *B. proteus* OX19; *H. pertussis*; bacillus of swine erysipelas.

Other similar compounds which have behaved in a manner comparable with phenol and tricresol are: ortho-, para- and meta-cresols, o-chlorphenol and p-chlorphenol. Further work is being carried out on the above observations.

For the testing of the antibodies, I am indebted to Mr. A. T. Glenny, Dr. C. L. Oakley, Mr. A. MacIntyre and Mr. H. Proom of the Wellcome Physiological Research Laboratories; and to Dr. A. Felix of the Medical Research Council.

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[1] Marrack, J. M., "The Chemistry of Antigens and Antibodies" (London: H.M. Stationery Office, 1938).
[2] Brit. Pat. No. 18340/1902.

Digitalis and Voluntary Muscle

The following interesting observation has been noted during class experiments on frog nerve-muscle dissections, and has been confirmed by later experiments. Due to shortages of frogs during the War, it was decided that fresh frogs be used first for the official method of assay of digitalis preparations and then for nerve-muscle experiments. Such animals received large doses of digitalis into the ventral lymph sac by way of the thigh muscle as seal, and it is known that these sublethal doses are not readily eliminated.

We were particularly interested in the effect of temperature on the nerve-muscle preparation supported in the normal muscle bath. To demonstrate the effect on the latent period, it was customary to use temperatures of 10°, 20°, 30° and 40° C. When the experiments commenced, it soon became evident that the muscles of these 'digitalis' animals were not standing up to such temperature variations, and lower values had to be employed to obtain class results. Further experiments were therefore carried out to demonstrate the effect of the recovery period (that is, the time after injection) on this abnormal response. The results, indicated in the accompanying table, although performed on a small number of animals, are fairly conclusive. An approximately equal number of control frogs (that is, uninjected) from the same batches of animals were used to show that the normal nerve-muscle preparation survived temperatures of 40°–42° C., with a small percentage (less than 10 per cent) failing to respond to temperatures greater than 40° C.

Effect of the recovery period on the response of the gastrocnemius muscle to temperature.

Days after digitalis injection	Frog nerve-muscle preparations at 36–39° C.	
	Not the normal response	Normal response
1	4	0
4	8	1
7	15	5
10	6	1
14	8	2
21	0	4
Totals	41	13

More than 50 per cent of those responding abnormally developed rigor; those which did not showed either feeble contraction at make and break or no effect on normal and direct muscular stimulation, with the same strength of stimulus. Alteration in excitability is thus indicated, digitalis apparently lowering the thermal threshold. It should be pointed out there was no correlation with dosage of digitalis in these experiments, and it is quite possible that the survivors above may have had smaller doses of the drug. The animals were all injected between October and January, but there was no uniformity as to the distribution of sex. All other experiments using the nerve-muscle preparations from 'digitalis' frogs behaved in a normal manner.

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Parasitism of *Striga* sp. on *Dolichos Lablab* Linn.

WHILE studying the possibility of germinating the seed of *Striga hermonthica* Benth. by means other than the excretions of the roots of gramineous plants it was found that excretions from the roots of many leguminous plants would also cause germination. Among these leguminous plants was Dolichos bean (*Dolichos Lablab* Linn.).

Experiments were therefore begun to discover if the growing of Dolichos bean in *Striga*-infested soil would rid the soil of the seed of this pest. It was found, however, that *Striga hermonthica* could parasitize the Dolichos bean with a consequent loss of crop.

In a pot experiment (fifteen replicates) in which Dolichos bean was sown in soil with and without *Striga* seed the results shown in Table 1 were obtained.

TABLE 1. MEAN DRY WEIGHT OF DOLICHOS BEAN.

Soil type	Leaf weight in gm.	Root weight in gm.
Without *Striga* seed	14·3	1·93
With *Striga* seed	8·1	1·75
Percentage loss due to *Striga*	43·3	9·1

The difference in leaf weight is very significant: that between root weight is not significant.

A second pot experiment (fifteen replicates) designed as the first experiment except that larger pots were used gave results shown in Table 2.

TABLE 2. MEAN DRY WEIGHT OF DOLICHOS BEAN.

Soil type	Leaf weight in gm.	Root weight in gm.
Without *Striga* seed	36·6	9·3
With *Striga* seed	13·6	5·3
Percentage loss due to *Striga*	62·4	43·0

The difference between leaf weight and root weight in the two series is very significant.

The difference in percentage loss due to *Striga* in the two experiments is probably due to the larger pots used in the second experiment, and to the fact that the experiments were started at different times of the year, the first experiment being sown in December and the second in September when better growth of the *Dolichos* was obtained.

The *Striga* plants on the roots of the *Dolichos* were small and appeared ill-nourished. When the experiments were ended (about three months after the sowing date) very few *Striga* plants had appeared about 1 cm. above ground, in contrast to the luxurious aerial growth that this parasite makes in that time on *Sorghum* spp.

It is hoped shortly to publish the full results of these experiments.

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Planck's Radiation Formula Derived without Atomicity

IN a recent paper[1] I expressed the fourth-power law of temperature radiation in a form analogous to the relativity expression of the laws of motion, so that the implication of unobservable absolute radiation was eliminated. In this expression temperature was measured by the rate of reception by a specified instrument of a quantity $d\eta$, corresponding to what is usually called entropy, time being measured on a thermal time-scale in which equal times correspond to equal receptions of η by a standard 'thermal clock'. It then appeared that what is usually regarded as the 'absolute entropy' radiated (that is, $\sigma\theta^4/\theta$), which was denoted by $d\sigma$, was invariant under changes of temperature of the η-measuring instrument and thermal clock according to transformation equations which were derived.

If we now add the postulate, guaranteed by experience, that radiation is associated with a continuous range of frequencies, its distribution among which varies with temperature, it follows that the quantity $d\sigma$ measured in unit thermal time must be expressed by a function $f(\tau,\nu)$ (τ is temperature on proposed scale; ν is frequency according to the thermal time-scale) which is invariant under the transformation referred to, and that this condition may serve to determine the function. The condition leads to the relation

$$\int_0^\infty f(\psi\,;\,\nu)d\nu \;=\; \int_0^\infty f(\psi\psi_1^{-1}\,;\,\nu\psi_1^{-3/4})d\nu,$$

where $\psi = 1 + \tau/\zeta$, $\psi_1 = 1 + \tau_1/\zeta$ in the notation of the paper referred to, ψ_1 corresponding to the temperature of the arbitrary 'co-ordinate system' to which the transformation is made; and the solution must satisfy this relation, be independent of ψ_1, must not be the product of independent functions of ψ and ν, and must make the integrals finite. The function $f(\psi\,;\,\nu) = A\nu^3$, corresponding to the Rayleigh–Jeans formula in the ordinary theory, does not meet these conditions, but the function

$$f(\psi\,;\,\nu) \;=\; \frac{A\nu^3\psi^{-1/4}}{\exp.\,B\nu\psi^{-1/4} - 1},$$

corresponding to the Planck formula, does so. I am not able to show that this solution is unique, but in view of the rather stringent conditions to be satisfied it seems likely that it is so. Integrating and equating the result to $d\sigma$ we find that $B^4 = 6{\cdot}495$ A., leaving one constant to be determined by experiment.

How far the theory can succeed in deriving results not yet known or fulfil its promise of a new thermodynamics expressed in relativistic instead of Newtonian terms remains to be seen. The immediate reaction on our understanding of physical conceptions, however, seems to me to be of considerable importance.

The Planck formula, which originally introduced the conception of the quantum and in view of which Poincaré, in the words of Jeans[2], "shows definitely and conclusively that the mere fact that the total radiation at a finite temperature is finite requires that the ultimate motion should be in some way discontinuous", is now derived with no appeal at all to any microscopic or discontinuous conceptions. The only postulates are the fourth-power law of radiation, the perfect gas equation, the periodic character of radiation, and the relativity principle that physical laws should be unaltered by changes having no absolute physical criterion. It is the last-named postulate that is omitted in the so-called 'classical' derivation of the energy-distribution law; the omission of the atomic character of radiation is a defect *only if the atomic character of matter is previously postulated*, but so far as the phenomenon of black-body radiation is concerned at least, the correct formula can be obtained without postulating any atomicity at all.

A revision of the customary view of the relation between macroscopic and microscopic laws would seem to be called for. The former are commonly regarded as the limit to which the latter approximate when the number of units concerned is very large, and therefore less fundamentally 'true'. The suggestion is now obvious that the macroscopic and microscopic laws are rather equally valid *alternative* expressions of observed relations, and that, as I have for long maintained on quite general grounds, the principle of indeterminacy, for example, is characteristic not of natural phenomena but of the particular terms of expression of phenomena which we have hitherto found it useful to adopt.

The result also, I think, confirms the view of time measurement in Einstein's relativity which I have previously put forward[3], according to which the 'time dilatation' would not necessarily characterize the readings of an actual clock unless that were an 'ideal' one (that is, a beam of light travelling along a space-measuring scale), and the intimate association of time with space has nothing to do with Nature but follows logically from the fact that we have chosen to *measure* time in terms of space measurement. In the new theory we measure time in terms of 'entropy', and so, in the same sense, time 'becomes' entropy. The change of frequency of radiation from the same body at the same Kelvin temperature, when measured in summer and winter, for example, is in the ratio of something like $(300/273)^3$ on the thermal scale, whereas on the conventional space scale it is nothing at all if the body does not move. It is impossible to reconcile this with the hypothesis of any 'absolute' change on either scale.

Details of the above work will appear shortly in the *Philosophical Magazine*.

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[1] *Phil. Mag.*, **35**, 499 (1944).
[2] "Radiation and the Quantum Theory" (second ed.), 29.
[3] *Nature*, **144**, 888 (1939); **146**, 391 (1940).

Geodesic Form of Schwarzschild's External Solution

THE line-elements usually appearing in relativistic cosmological studies are particular cases of the geodesic line-element[1],

$$ds^2 \;=\; d\tau^2 + \sum_{i=1}^{3}\sum_{j=1}^{3} g_{ij}dx^i dx^j, \quad . \quad . \quad . \quad (1)$$

$$g_{ij} \;=\; g_{ij}\,(x^1, x^2, x^3, \tau),$$

obtainable from the most general form by subjecting the co-ordinate system to the restrictions[2],

$$\Gamma^{\alpha}_{41} \;=\; 0, \quad \alpha \;=\; 1, 2, 3 \quad . \quad . \quad . \quad (2)$$

and then choosing τ suitably. The conditions (2) imply that the world-line (x^1, x^2, x^3) is a geodesic . . . . . (3)

If observers in a gravitational field are required to be on geodesics, the form (1) is therefore the most convenient from the observer's point of view. A particular case of (1) having spherical symmetry is

$$ds^2 \;=\; d\tau^2 - e^{\lambda}d\rho^2 - \rho^2 e^{\mu}\,(d\theta^2 + \sin^2\theta d\varphi^2), \quad . \quad (4)$$

where $\lambda \;=\; \lambda(\rho,\tau)$, $\mu \;=\; \mu(\rho,\tau)$.

The most general solution of the form (4) of the field equations,

$$G_{\mu\nu} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

is given by

$$e^{\lambda} = \left[\chi(\rho) + \frac{2\rho}{3}\frac{d}{d\rho}\chi(\rho)\right]\left[\chi(\rho) \pm \frac{3}{2}\frac{\sqrt{zm}\tau}{\rho^{3/2}}\right]^{-2/3},$$

$$e^{\mu} = \left[\chi(\rho) \pm \frac{3}{2}\frac{\sqrt{zm}\tau}{\rho^{3/2}}\right]^{4/3}, \quad . \quad . \quad . \quad (6)$$

where a is an arbitrary constant and $\chi(\rho)$ an arbitrary differentiable function of ρ. It is found to be a transform of Schwarzschild's external solution:

$$ds^2 = \left(1 - \frac{2m}{r}\right)dt^2 - \left(1 - \frac{2m}{r}\right)^{-1} dr^2 - r^2\,(d\theta^2 + \sin^2\theta d\varphi^2). \quad . \quad . \quad . \quad . \quad (7)$$

If we put $a = 2m$ and $\chi(\rho) = 1$, (6) reduces to

$$ds^2 = d\tau^2 - \left[1 \pm \frac{3}{2}\frac{\sqrt{2m}\tau}{\rho^{3/2}}\right]^{-2/3} d\rho^2 - \rho^2\left[1 \pm \frac{3}{2}\frac{\sqrt{2m}\tau}{\rho^{3/2}}\right]^{4/3}(d\theta^2 + \sin^2\theta d\varphi^2). \quad . \quad . \quad (8)$$

which is connected with (7) through the transformation,

$$r = \rho\left[1 \pm \frac{3}{2}\frac{\sqrt{2m}\tau}{\rho^{3/2}}\right]^{2/3},$$

$$t = \tau - \tau_0 \pm 2\sqrt{2m}\left(\rho^{3/2} \pm \frac{3}{2}\sqrt{2m}\tau\right)^{1/2} \pm 2m \log \frac{\left(\rho^{3/2} \pm \frac{3}{2}\sqrt{2m}\tau\right)^{1/2} - \sqrt{2m}}{\left(\rho^{3/2} \pm \frac{3}{2}\sqrt{2m}\tau\right)^{1/2} + \sqrt{2m}}, \quad . \quad . \quad (9)$$

τ_0 being an arbitrary constant. The Jacobian of the transformation is

$$\frac{\delta(r,t)}{\delta(\rho,\tau)} = \left(\frac{\rho}{r}\right)^{1/2} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Comparing (7) with (8), we find that the former gives flat space when $m = 0$ or as $r \to \infty$, while the latter does so when $m = 0$ or $\tau = 0$ or as $\rho \to \infty$. The form (8) requires m to be positive. For (7) one has to assume that m is positive. The condition (3) is fulfilled for (7) only as $r \to \infty$, while it is true everywhere for (8)[3].

A detailed investigation of the new line-elements (8) will be published elsewhere.

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[1] Eisenhart, L. P., "Riemannian Geometry, 57 (1926).
[2] Weyl, H., "Space, Time and Matter", 275 (1922).
[3] Narlikar, V. V., *Mon. Not. Roy. Ast. Soc.*, **93**, 263 (1936).

A Simple Proof of the Lorentz Transformation

It appears that the following proof of the Lorentz transformation, which occurred to me when preparing a lecture on relativity, is not generally known among students of relativity, though I would be surprised if it has not been discovered before.

Let $\Sigma\,(x,y,z,t)$ and $\Sigma'\,(x',y',z',t')$ be two systems of reference in uniform motion with respect to one another. Let the x- and x'-axis be in the direction of motion. Let v be the velocity of Σ' measured in Σ. Its value depends on the scales adopted in Σ for the measurement of length and time and also on the definition of synchronism used in Σ for events in Σ. We assume that the scales and the definition of synchronism used in Σ' are such that the velocity of Σ measured in Σ' has the value $-v$.

It then follows that the transformation formulæ are:

$$y' = y, \quad z' = z$$
$$x' = f_{11}(v)\,x + f_{12}(v)\,t \quad . \quad . \quad (1a)$$
$$t' = f_{21}(v)\,x + f_{22}(v)\,t \quad . \quad . \quad (1b)$$

and that the transformation matrix

$$F(v) = \begin{pmatrix} f_{11}(v) & f_{12}(v) \\ f_{21}(v) & f_{22}(v) \end{pmatrix}$$

fulfils the postulate

$$F(-v) = F(v)^{-1}. \quad . \quad . \quad . \quad . \quad . \quad (P1)$$

Let now $\Sigma''\,(x'',y'',z'',t'')$ be a third system of reference with its x''-axis parallel to the x'-axis and moving along the latter with the uniform velocity v' as measured in Σ'. The matrix of the transformation $\Sigma \to \Sigma''$ is then the product matrix $F(v')F(v)$. If, on the other hand, we introduce the intermediate System Σ' so that its velocity in Σ is v' and hence the velocity of Σ'' in Σ' is v, the same transformation is given by $F(v)F(v')$. Hence

$$F(v)F(v') = F(v')F(v). \quad . \quad . \quad . \quad (P2)$$

The two postulates ($P1$) and ($P2$) together with the definition of the group parameter v suffice to evaluate the four functions $f_{ik}(v)$.

By writing down the four equations ($P1$) and hence forming the determinant $D(-v) = \det[F(-v)]$ it is seen that $D(-v) = D(v)/D(v) = 1$. Hence

$$D(v) = \det[F(v)] = 1. \quad . \quad . \quad (I)$$

The four equations ($P1$) then reduce to

$$f_{11}(-v) = f_{22}(v) \quad (2{\cdot}11) \qquad f_{12}(-v) = -f_{12}(v) \quad (2{\cdot}12)$$
$$f_{21}(-v) = -f_{21}(v) \quad (2{\cdot}21) \qquad f_{22}(-v) = f_{11}(v) \quad (2{\cdot}22)$$

of which the first and the last are identical. To these equations ($P2$) adds one, and only one, new functional equation:

$$f_{12}(v)/f_{21}(v) = f_{12}(v')/f_{21}(v') = \text{invariant} = C^2. \quad (3)$$

The results so far obtained may be summarized as follows:

$$F(v) = \begin{pmatrix} f_{11}(v) & f_{12}(v) \\ f_{12}(v)/C^2 & f_{11}(-v) \end{pmatrix}, \quad f_{12}(-v) = -f_{12}(v). \quad (II)$$

We now make use of the definition of v as the velocity of Σ' in Σ, that is, $v = x/t$, where x and t are corresponding co-ordinates in Σ of the point $x' = 0$. Hence from (1a):

$$v = -f_{12}(v)/f_{11}(v). \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Since $f_{12}(v)$ is an uneven function of v, it follows that $f_{11}(v)$ is an even function:

$$f_{11}(-v) = f_{11}(v). \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Hence the matrix $F(v)$ reduces to

$$F(v) = f_{11}(v) \cdot \begin{pmatrix} 1 & -v \\ -v/C^2 & 1 \end{pmatrix} \quad . \quad (III)$$

From (I) we obtain

$$f_{11}(v) = [1 - v^2/C^2]^{-1/2}. \quad . \quad . \quad . \quad (IIIa)$$

From the last formula, or more convincingly from the theorem of composition of velocities, it is seen that the invariant C is the limiting velocity.

Since the postulates ($P1$) and ($P2$) can always be satisfied by a suitable choice of the definitions involved, it appears that the Lorentz transformation has a more general significance than seems to be widely believed. Indeed, the only question left for the experimenter to decide is what signals have the limiting velocity C, and what is its value in a given system of units. In particular, the Galilean transformation does not logically contradict the Lorentz transformation but is its degenerated form for $C = \infty$. In order to establish the Special Theory of Relativity, no other empirical fact need be used than that for any given system of reference the velocity of light is the limiting velocity.

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A Generalization of Special Relativity Theory

In an attempt to treat gravitational and electromagnetic phenomena simultaneously within the framework of the special theory of relativity, it has been suggested[1] that the Maxwell–Lorentz equations may be generalized to five dimensions and derivatives with respect to the fifth co-ordinate equated to zero. One may similarly generalize to five dimensions with special relativistic dynamics of a continuous medium, identifying the extra components of the mechanical stress tensor as follows:

$$T^{i5} = c\mathfrak{j}, \; c^2\rho, \; c^2\sigma_0,$$

where $\mathfrak{j}$, ρ, σ_0 denote the current, charge and rest-mass densities. Assuming that this macroscopic tensor may be added to the corresponding microscopic tensor characteristic of the field, it is found that associated with a gravito-electromagnetic field there exist charge and current densities given by

$$c\mathfrak{j}(f) = \mathbf{H} \times \mathbf{F} - \mathfrak{G}\mathbf{E}; \quad c^2\rho(f) = -\mathbf{E}\cdot\mathbf{F};$$

where $\mathbf{F} = -\nabla\Omega$, $c\mathfrak{G} = \dot{\Omega}$, and Ω is the gravitational potential of the consequent scalar gravitational theory.

These equations imply that mass and momentum, but not charge, may be created from the field at points unoccupied by matter, and that, although charge may be carried by the field, the net charge radiated per unit time over a distant boundary by an accelerated charge vanishes identically. It also follows that the charge and current densities in Maxwell's equations should include $\rho(f)$ and $\mathfrak{j}(f)$ respectively, so that in general they are non-zero even in material-free space.

Not only the rest-mass but also the charge of a particle are shown to be functions of the gravitational potential:

$$m_0 = m_{00} \exp.(\Omega/c^2); \quad e = e_{00} \exp.(\Omega/c^2).$$

Hence the force between two particles tends to zero as they approach each other indefinitely.

The assumption of flat space-time with

$$\frac{\partial}{\partial x^5} = 0$$

yields a scalar gravitational theory similar to the earlier theory of Nordström[2] and leaves out of account the remarkable successes of the general theory of relativity. The results to which the above theory leads should therefore be treated with caution. Nevertheless, one is thus able to formulate a relativistically covariant special theory from which the infinite forces of classical electromagnetic theory are absent.

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[1] Nordström, G., *Phys. Z.*, **15**, 504 (1914). Corben, H. C., *Nature*, **156**, 388 (1945).
[2] Nordström, G., *Phys. Z.*, **13**, 1126 (1912).

Postulates of Probability

THE concept of probability has always comprised two ideas: that of frequency in an ensemble and that of reasonable expectation. Suppose it is said that in tossing an unbiased coin the probabilities of heads and tails are equal. It is implied that the fraction of tosses giving heads will be the same as the fraction giving tails in a large enough number of tosses. It is implied also that in a single trial there is as much reason to expect one result as the other. The choice of one or the other of these ideas as the primary meaning of probability distinguishes the two main schools of thought in the field.

In some examples of probable inference, however, only the idea of reasonable belief is involved. Suppose it is said that one theory of the origin of our solar system is more probable than another. It is meant that one theory is more entitled to belief than the other, not that our solar system originated more often in one way than the other. The opinion which derives probability from frequency in an ensemble must exclude such inference as this from the theory. The distinction which this requires between the cases to be admitted and those to be excluded will often be very tenuous indeed.

On the other hand, the theory based upon reasonable expectation has offered some difficulty because of the vagueness of this concept. Probabilities become calculable in this theory only after the concept has been supplemented by a number of axioms. The necessity of an axiomatic approach has been forcefully argued by Keynes[1], and sets of axioms have been stated with clarity by him and by Jeffreys[2] and others. But detached from the concept of the ensemble these rules have an appearance of artifice which has hindered the acceptance of this view of probability. The purpose of the present note is to point out that more primitive postulates will suffice. It is only necessary to make more use than has been done heretofore of the Boolean algebra of symbolic logic.

The first of these more primitive postulates concerns the probability that both of two events will occur. Let it be assumed only that this probability is determined in some way by the probability of the first event in the given circumstances and the probability of the second event, given these circumstances and the occurrence of the first event. Suppose a bill has been introduced in one house of a bicameral legislature. The probability that it will pass both houses involves first of all the probability that it will pass the first house. It involves further the probability of passage in the second house, passage in the first house being assumed. In more general terms, let **a**, **b** and **c** denote propositions, **a** being given as hypothesis. Let **c·b** denote the joint proposition **c**-and-**b** and **b·a** the joint proposition **b**-and-**a**. Let **b**|**a** and **c·b**|**a** denote the respective probabilities of **b** and **c·b** on the hypothesis **a**. Similarly let **c**|**b·a** denote the probability of **c** on the hypothesis **b·a**. The postulate made above is that **c·b**|**a** is a function of **b**|**a** and **c**|**b·a**.

It can be shown that, with this postulate, Boolean algebra requires that

$$C\,f(\mathbf{c}\cdot\mathbf{b}|\mathbf{a}) = f(\mathbf{c}|\mathbf{b}\cdot\mathbf{a})\,f(\mathbf{b}|\mathbf{a}).$$

where f is an arbitrary function of a single variable and C is an arbitrary constant. Thus far, probability has been identified only as some measure of reasonable belief. If **b**|**a** is one such measure, then $f(\mathbf{b}|\mathbf{a})$ is another and may just as well be called the probability. It is immaterial whether we use the symbol **b**|**a** or $f(\mathbf{b}|\mathbf{a})$. For simplicity we write, therefore,

$$C(\mathbf{c}\cdot\mathbf{b}|\mathbf{a}) = (\mathbf{c}|\mathbf{b}\cdot\mathbf{a})\,(\mathbf{b}|\mathbf{a}).$$

Consideration of the case in which **c** is the same proposition as **b** identifies the constant C with the probability of certainty. This is conveniently, though not necessarily, given the value unity.

The second postulate is this: the probability that a proposition is false is determined by the probability that it is true. The symbolic statement is that $\sim\mathbf{b}|\mathbf{a}$ is a function of **b**|**a**, where $\sim\mathbf{b}$ denotes the proposition not-**b**. Consistency with Boolean algebra now requires that

$$(\sim\mathbf{b}|\mathbf{a})^m + (\mathbf{b}|\mathbf{a})^m = 1,$$

where m is an arbitrary number. If **b**|**a** is a measure of reasonable belief, so also is $(\mathbf{b}|\mathbf{a})^m$. We may therefore call $(\mathbf{b}|\mathbf{a})^m$ the probability or, making a choice which is different only in form, we may let $m = 1$ and write

$$\sim\mathbf{b}|\mathbf{a} + \mathbf{b}|\mathbf{a} = 1.$$

The application of Boolean algebra to the rules already obtained yields others, of which the most important are

$$\mathbf{c}\cdot\mathbf{b}|\mathbf{a} = \mathbf{b}|\mathbf{a} \text{ and } \mathbf{c}\vee\mathbf{b}|\mathbf{a} + \mathbf{c}\cdot\mathbf{b}|\mathbf{a} = \mathbf{c}|\mathbf{a} + \mathbf{b}|\mathbf{a}$$

where **c** ∨ **b** denotes the disjunctive proposition **c**-or-**b**.

A longer discussion, including the mathematical derivations, is soon to appear in the *American Journal of Physics*.

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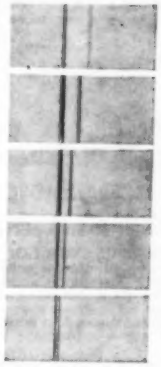
[1] Keynes, J. M., "A Treatise on Probability" (London, 1929).
[2] Jeffreys, H., "Theory of Probability" (Oxford, 1939).

Large Dispersion in X-ray Spectrography Obtained by Using Ground Faces

GROUND faces of calcite can be used with the view of obtaining large dispersion in X-ray spectrography. In a paper published in 1944[1], I showed that a face ground parallel to the lattice plane 655 (Miller's notation in the primitive lattice) yielded good results. The spacing for this plane is 1·032 A. Since then, I have made attempts with faces ground parallel to the planes 741 and 10·3·3, for which the spacings are 0·716, and 0·533 A. respectively. In the accompanying



Molybdenum Ka_1a_2 in the first order.

reproduction the molybdenum Ka-doublet in the first order is recorded for a series of natural (211 and 310) and ground (655, 741 and 10·3·3) faces on calcite from Iceland. The photographs were obtained in a vacuum spectrograph of the Siegbahn type with an effective radius of 18 cm., 2-fold magnification.

TABLE 1. $\frac{d\theta}{d\lambda} \cdot 10^{-7}$

pqr	d	MoKα_1 λ = 0·708A.	CuKα_1 λ = 1·537A.	ScKα_1 λ = 3·025A.
10·3·3	0·533 A.	12·55	—	—
741	0·716 A.	8·03	—	—
655	1·032 A.	5·16	7·26	—
310	1·532 A.	3·37	3·80	—
211	3·029 A.	1·66	1·71	1·90

The accompanying table shows the values of $\frac{d\theta^1}{d\lambda}$ for five lattice planes of calcite and for three Ka_1 lines (molybdenum, copper and scandium). From these values the calculation of the displacement of a line on the film for a change in λ of $\triangle\lambda = 1$ X.U. is made by means of the formula

$$D_{pqr} = 2 \times 10^{-11} \times \frac{d\theta}{d\lambda} \times R \text{ cm.},$$

where R is the radius of the spectrograph and θ the reflexion angle.

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[1] *K. Vetenskapsakad. Ark. Kemi*, etc., **18** B, No. 14 (1944).

Accuracy of Atomic Co-ordinates Derived from X-ray Data

PREVIOUS work[1,2] on this topic led to methods and formulæ applicable to three-dimensional summation, and it was obviously desirable to extend this to the more limited (and usual) two- and one-dimensional cases. This has now been done, and in a paper, to appear in full elsewhere, I have obtained general results valid for the more simple types of series.

Finite summation errors are shown, in a diatomic case, to be of the same order whatever the dimensions of the series, provided that the resolution is the same in each case; resolution being here defined as the distance between atomic peaks *in the particular synthesis*.

On the basis of the above treatment, it is shown that if a set of observed $|F|$ values is terminated, by real thermal motion, at reciprocal spacing ρ ($= 2\sin\theta$); the errors in atomic co-ordinates, δ_n, are given by:

$$\delta_n \propto 1/\rho^{(3+n)/2},$$

where n is the number of dimensions of summation. This relation makes possible a comparison of the errors in different structures containing the same type and number of atoms.

The 'artificial temperature factor' method[3,4] of ensuring convergence is also examined, and is shown to introduce errors greater than those for the elimination of which it is applied; suggestions are made, however, as to the way in which corrections may be made for these.

Finally, the effect of experimental errors, in all cases, is reduced to the simple formula:

$$\varepsilon_n < 0{\cdot}66\ \Delta e/(N\sqrt{v_n}).$$

Here $\triangle e$ is the probable experimental error in the $|F|$ values (*c.* 0·6[3]); N is the atomic number of the atom under consideration; v_n is the 'volume' of the repeat unit for dimensions of summation n; ε_n is the mean error in Å. of the atomic parameters. In a particular case

this leads to errors: $\varepsilon_1 = 0{\cdot}027$ A.; $\varepsilon_2 = 0{\cdot}008$ A.; $\varepsilon_3 = 0{\cdot}002_7$ A. Hence the three dimensional series is seen to be greatly superior in this respect.

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[1] Booth, *Nature*, **158**, 51 (1945).
[2] Booth, *Proc. Roy. Soc.*, in the press.
[3] Bragg and West, *Phil. Mag.*, **10**, 823 (1930).
[4] van Reigen, *Physica*, **9**, 461 (1942).

Crystal Structure of Sodium Nitroprusside

Sodium nitroprusside, $Na_2Fe(CN)_5NO.2H_2O$, crystallizes in the bipyramidal class D_{2h} or *mmm* (di-digonal equatorial or holoaxial) of the orthorhombic system. The forms exhibited are the {110} primary rhombic prism, the {010} brachy-pinakoid and the {011} primary brachy-domal prism. The crystals are needle-like in habit along the *c*-axis and the unit cell dimensions determined from rotation photographs are: $a = 11{\cdot}8$ A.; $b = 15{\cdot}52$ A.; $c = 6{\cdot}22$ A.

Absent spectra indicate two *n* glides of components $\left(\frac{a}{2} + \frac{b}{2}\right)$ and $\left(\frac{b}{2} + \frac{c}{2}\right)$ and the space group is D_{2h}^{11} or *Pnnn* with four molecules per unit cell.

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Decomposition of Martensitic Steel Above and Below 300° C.

During the course of an investigation concerning metallurgical structures employing both the electron microscope and electron diffraction reflexion methods, some interesting, and perhaps important, results were obtained with a plain carbon steel. The literature dealing with the tempering of martensite at low temperatures generally assumes that the decomposition below 300° C. produces a very highly dispersed carbide phase[1]. It was generally concluded that the carbide particles are so small and are sufficiently deformed by stresses set up during precipitation that a satisfactory X-ray pattern could not be expected.

Electron diffraction reflexion patterns from etched surfaces of a plain carbon steel (0·9 per cent C, 0·15 per cent Si) clearly indicate that martensite aged at 200° C. produces a fine dispersion of hexagonal Fe_2N as a reaction product with no trace of Fe_3C. Above 300° C., the reaction product is found to be Fe_3C, as previously concluded from X-ray studies. Further, a specimen aged first at 200° C. to produce highly dispersed Fe_2N will, upon heating at 350° C., become transformed to Fe_3C. After half an hour at 350° C., the pattern indicates the presence of both Fe_2N and Fe_3C. It appears that at low temperatures Fe_2N is the stable product, while above 300° C., Fe_3C is the equilibrium product. A nitrogen analysis of the samples gave 0·0056 per cent N.

The data are too meagre for any conclusions as to mechanism, but it is of interest to speculate on the decomposition reactions. The following sequence of reactions is offered as a possible mechanism.

$$1.\quad \overbrace{Fe + C_{soln.} + N_{soln.}}^{\text{Martensite}} \xrightarrow{200°C.} Fe_2N + C_{soln.}$$

or

$$\xrightarrow{200°C.} Fe_2(CN) + C_{soln.}$$

$$2.\quad \overbrace{Fe + C_{soln.} + N_{soln.}}^{\text{Martensite}} \xrightarrow{400°C.} Fe_3C + N_{soln.}$$

$$3.\quad Fe_2N + C_{soln.} \xrightarrow{350°C.} Fe_3C + N_{soln.}$$

or

$$Fe_2(CN) + C_{soln.} \xrightarrow{350°C.} Fe_3C + N_{soln.}$$

The determination of specific rates and activation energies is possible by means of electron diffraction and will be essential in understanding the decomposition.

The surface preparation of the samples which produced satisfactory results was briefly as follows: (1) specimen abraded through 4/0 metallographic paper; (2) electrolytically polished; (3) etched 60–90 sec. in a solution of 2 per cent hydrochloric acid and 1 per cent ferric chloride in methanol; (4) rinsed in the following sequence of solutions: (*a*) 50 : 50 acetone-methanol plus 0·5 per cent formic acid; (*b*) 50 : 50 acetone-methanol; (*c*) dry benzene. (5) dried in blast of clean, dry air. The surfaces so produced are sufficiently clean to yield good electron diffraction patterns and electron microscope pictures.

The patterns were taken with a camera employing a 75 cm. plate-specimen distance and using 40 kV. electrons. Measurements from the patterns as compared to X-ray powder results make the identification quite certain.

The first results indicate that the use of electron diffraction may greatly aid in investigating metallurgical transformations where very small quantities of the reaction products are concerned. It is hoped that a thorough study of the transformations in steel will be made by these methods. It appears that thoroughly degassed metal should make a suitable starting point for an investigation.

A fuller account of this work will be published elsewhere.

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[1] Barrett, C. S., "Structure of Metals" (McGraw-Hill, New York, 1943), 479.

Molecular Weight and Polydispersity of Rubber by Diffusion Measurements

The study of diffusion in solutions of natural rubber (light crepe) by Lamm's[1] method showed that even with a concentration of 0·1 per cent the normalized experimental diffusion curves diverge from the ideal Gaussian curve (Fig. 1), being characterized by a marked asymmetry and an excess of the maximal ordinate. It follows from an analysis of the experimental curves by the method of moments (up to moments of the fourth order) that they belong to Type IV Pearson curves, that is, to asymmetrical distribution curves with asymptotic branches. The determination of the perturbation multiplier enables us to calculate the course of the experimental curves with a fair degree of accuracy. The physical cause of asymmetry of the diffusion curves is the difference in the rate of diffusion to both sides of the interface (of the polymer into the solvent and back) due to a marked intermolecular interaction in the solution of the polymer at a given concentration. With a decrease of the concentration or of the molecular weight of the dissolved substance, the asymmetry of the diffusion curves becomes less pronounced. However, this asymmetry does not preclude the computation of the average diffusion coefficient D from the standard deviation of the curve. It can indeed be shown that the probable error does not exceed 1 per cent. The average value found for natural rubber in carbon tetrachloride is $D_{25°} = 0{\cdot}71 \times 10^{-7}$ cm.²/sec.

Fig. 1. Gaussian curve (full line); experimental curve (broken line); calculated points (dots).

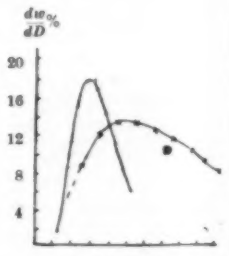

Fig. 2. Curves for natural rubber (dots) and natural rubber after thermal destruction (crosses).

The asymmetry of the rubber molecules was calculated from the viscosity of rubber solutions by Simha's equation[2], the applicability of which for the computation of the ratio (b/a) of even highly asymmetrical particles with $b/a = 70$–90 has been verified experimentally with nitrocellulose[3]. The flexibility of the rubber molecules is here of no particular significance, as under the conditions of the experiment the forces of flow are below the critical value necessary for the deformation of the molecular coil[4]. Computation shows that for natural rubber $(b/a) = 117$–120 and $(f/f_0) = 4{\cdot}35$–$4{\cdot}40$. By combining the values of D and (f/f_0) by Polson's method[5], we find that at a concentration of 0·116 per cent the molecular weight of natural rubber is $M = 830{,}000$. Lansing and Kraemer's figure obtained[6] by the ultracentrifugation method for a 0·05 per cent solution is M is 400,000–435,000. In both cases there undoubtedly occurs aggregation in the solution. Extrapolation of these results to $G = 0$ gives M equal to 130,000–150,000, which is presumably the true molecular weight of natural rubber.

Figures very close to this were obtained for natural rubber twice precipitated from a carbon tetrachloride solution by excess of alcohol, namely, $D_{25°} = 0{\cdot}66 \times 10^{-7}$ cm.²/sec.; $b/a = 123$; $f/f_0 = 4{\cdot}45$; $M = 970{,}000$ (at a concentration 0·135 per cent). After thermal destruction of rubber caused by exposure for three hours to 140° in air the molecular characteristics changed abruptly: $D_{25°} = 1{\cdot}6 \times 10^{-7}$ cm.²/sec.; $b/a = 88$; $f/f_0 = 3{\cdot}85$; $M = 103{,}000$ (for a 0·135 per cent solution).

The following are the figures obtained for an industrial specimen of divinyl synthetic rubber: $D_{25°} = 2{\cdot}1 \times 10^{-7}$ cm.²/sec.; $b/a = 65$; $f/f_0 = 3{\cdot}31$; $M = 73{,}000$ (for a 0·112 per cent solution); the normalized diffusion curve has in this case a quite symmetrical character.

A comparison with the results of calculation of M from Staudinger's equation ($K_m^{carb.\ tetrachl.} = 3 \times 10^{-4}$) showed that at $M \sim 100{,}000$ and less this equation gives good agreement with M, whereas with $M \sim$

800,000 the figures are several times less. Thus, for natural rubber M_{St} = 193,000 instead of 830,000, but for synthetic rubber M_{St} = 68,000 instead of 73,000. This result is in good agreement with data in the literature.

One can compute, on a model of an elongated ellipsoid, the length $l = 2b$ of the particles from the values of M and b/a. For natural rubber we obtain in this way l = 3500 A., whereas from the depolarization of diffuse light l was found to be 3400 A. for the same system (0·1 per cent solution of natural rubber in carbon tetrachloride)[7].

Thus it appears that Polson's method can be applied to linear polymers over a wider range than might have been theoretically presumed.

All the rubber samples studied are characterized by an appreciable excess of the maximal ordinate of the normalized experimental diffusion curve over the ideal curve (this appears also from Fig. 1), thereby indicating polydispersity of these substances. Gralén[8] suggested a convenient method of quantitative estimation of polydispersity as characterized by the ratio of the diffusion coefficients D_s/D_1 computed from the standard deviation and from the maximal ordinate of the diffusion curve. For a monodisperse substance, $D_s = D_1$ or $D_s/D_1 = 1$; for natural rubber we have found $D_s/D_1 = 1{\cdot}17$, after a twofold precipitation $D_s/D_1 = 1{\cdot}18$, after thermal destruction $D_s/D_1 = 1{\cdot}72$, etc. Assuming the logarithmic course of the distribution curve, one can, after Gralén, calculate from D_s/D_1 complete distribution curves (Fig. 2), and thus obtain a more demonstrative picture of polydispersity of the substance. Finally, it can be shown that in the general equation for asymmetrical particles, $M = -K/D^2$, the value of a for natural rubber is 1·1 (for nitrocellulose Gralén obtained a = 1·2); whence it follows that for linear polymers the change of D follows very closely the change in the molecular weight.

On the whole, the application of the above methods to the rubber-like polymers enables one to obtain from the diffusion and viscosity measurements a fairly complete molecular characterization of these substances. This is particularly significant for laboratories which do not possess an ultracentrifuge.

A full account of this work will be published in the near future in *Acta physicochim. USSR.*

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Oct. 22.

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[2] Simha, R., *J. Phys. Chem.*, **44**, 25 (1940). Mehl, J., Oncley, J., and Simha, R., *Science*, **92**, 131 (1940).
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[4] Frenkel, J., *Acta Physicochim.*, **19**, 51 (1944).
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[6] Cited in Davis and Blake, "The Chemistry and Technology of Rubber" (1937), 232.
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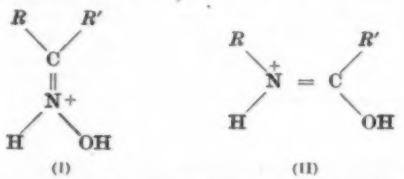
[8] Gralén, N., *Koll. Z.*, **95**, 188 (1941).

Mechanism of the Beckmann Rearrangement

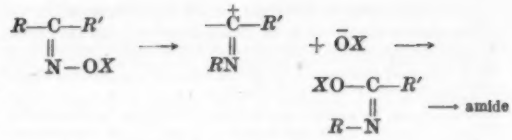
The recent resurgence of interest in the mechanism of the Beckmann change reflects the perennial fascination which this subject has for chemists. First, Higman[1] and LeFevre[2] have suggested that the cation (I) rearranges by rotation of the central pair >C=N< through 90° to form (II).



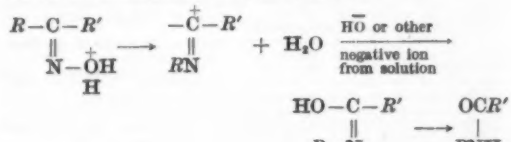
(I) (II)

Such a mechanism, as Dewar[3] has pointed out, is completely at variance with the data obtained from careful studies of the rearrangements of the picryl ethers and the benzene sulphonyl esters of ketoximes[4]. Secondly, Brodsky and Miciuchin[5], in some recently available publications, have questioned the correctness of the usually accepted view of the intramolecular nature of the transformation because the benzanilide formed by the addition of water, containing an excess of the heavy isotope O^{18}, to the product resulting from the rearrangement of benzophenone oxime by phosphorus pentachloride itself contained O^{18}.

In any formulation of the mechanism of the Beckmann rearrangement, it has to be remembered that the change involves the migration of two radicals: (*a*) the hydrocarbon radical R from carbon to nitrogen, and (*b*) the OH or OX group from nitrogen to carbon. Campbell and Kenyon's elegant demonstration[6] that the product resulting from the rearrangement of the oxime of (+)-α-phenylethylketone, in which the migrating group is linked to the rest of the molecule by an asymmetric carbon atom, possesses 99·6 per cent of the activity of optically pure (−)-aceto-α-phenylethylamine relates to process (*a*) only, but it proves conclusively that the asymmetric migrating group is never kinetically free: electron-sharing between it and the remainder of the molecule must be continuous throughout the rearrangement. With regard to process (*b*), there is as yet no clear-cut evidence as to the mode of transit of OX from nitrogen to carbon; this may occur by an intramolecular route or by dissociation into free ions. Although the data are well interpreted by an intramolecular migration, there is in the picryl ethers and benzene sulphonyl esters no reason to object to the mechanism:



nor for the rearrangement by an acid reagent to



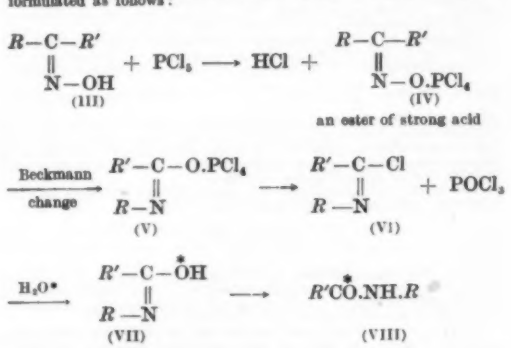
Indeed, Chapman[7] has found that when a mixture of the homopicryl (that is, 2 : 4 : 6-trinitro-*m*-cresyl) ether of benzophenone oxime and the picryl ether of the oxime of di-*p*-tolylketone undergoes rearrangement on heating the product contains some *p*-toluoyl-*N*-homopicryl-*p*-toluidide, $p\text{-Me.C}_6\text{H}_4\text{.CO.N}\langle^{\text{C}_6\text{H(NO}_2)_3\text{.Me}}_{\text{C}_6\text{H}_4\text{.Me}(p)}$. This may arise as the result of the ionization of OX but, on the other hand, it may conceivably be the consequence of exchange in the picryl ethers before rearrangement.

If, however, ionization occurs, it must either occur simultaneously with, or after migration of, the group R. It cannot precede it, otherwise there would not be such a strict stereochemical determination of the products in rearrangements of this kind.

The new evidence of Brodsky and Miciuchin, based on the use of the isotope O^{18} from which it is concluded that the rearrangement is not intramolecular, is open to criticism because of the use of phosphorus pentachloride. Although its function in the Beckmann rearrangement has never been fully worked out, its action on the oxime is presumably similar to that on other hydroxy compounds, namely:

$$ROH + PCl_5 \rightarrow RO.PCl_4 + HCl \rightarrow RCl + POCl_3 + HCl.$$

If this be so, then its role in the rearrangement of a ketoxime may be formulated as follows:



an ester of strong acid

(V) (VI) (VII) (VIII)

Compound (V) on decomposition can give rise to an oxygen-free compound (VI), which will inevitably yield with water enriched with the heavy isotope O^{18} an amide (VIII) containing O^{18}. It is therefore clear that although process (*b*) may well prove in fact to be an intermolecular process, the new data of Brodsky and Miciuchin do not by themselves disprove an intramolecular mechanism of the transformation.

From the combined data at present available, it may be concluded that the Beckmann change involves: (*a*) an intramolecular migration of the hydrocarbon radical R from carbon to nitrogen, and (*b*) a simultaneous or subsequent transfer of the group OX to the carbon atom (with the eventual formation of the amide) which is possibly intermolecular in character.

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[3] Dewar, *Nature*, **156**, 688 (1945).
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[6] Campbell and Kenyon, *J. Soc. Chem. Ind.*, **49**, 391 (1945), and private communication.
[7] Chapman, private communication.

Activation of Catalysts in Olefin Reactions

THE observations recorded by Evans *et al.*[1] establish that boron trifluoride alone cannot cause the polymerization of *iso*-butene or of di-*iso*-butene unless some unidentified promoter is present. It is the intention of this letter to direct attention to a number of similar observations affecting olefin reactions.

Ethylene is not polymerized by pure aluminium chloride at temperatures below 50° unless traces of hydrogen chloride or moisture are present[2]. The reaction of olefins with *iso*-paraffins and with aromatic hydrocarbons under the influence of aluminium chloride and certain other inorganic chlorides is promoted by hydrogen chloride[3]. Similarly, boron trifluoride will not catalyse reaction between an olefin and an *iso*-paraffin unless small amounts of water or hydrogen fluoride and a finely divided metal are present[4].

If hydrogen halide is the common promoter in all these reactions, we may assume that its primary action is the same in each. The most promising suggestion is that olefin acts as a proton acceptor. The function of the catalyst is to cause reaction between a charged olefin addendum and the other reactant. This hypothesis has the advantage of providing a common explanation of the catalytic action of inorganic halides and also of hydrogen fluoride and of sulphuric and phosphoric acids in bringing about all the reactions mentioned above.

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The University,
Birmingham, 15.

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WE regret to have left unmentioned the facts referred to by Dr. Hickinbottom. They may have some bearing on our findings, but it is too early to discuss this at length. We may mention, however, that the action of titanium chloride ($TiCl_4$) on *iso*butene at low temperature which we found to be induced by traces of water is not affected by dry hydrogen chloride.

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A Dropping Mercury Electrode of Improved Sensitivity

Lingane and Loveridge[1] have recently emphasized the desirability of using a capillary electrode with drop-time between one and six seconds in polarographic work. For a given tube, the drop-time (τ) is inversely proportional to the rate of flow of mercury (m), which may be increased by altering the height of the mercury reservoir or the dimensions of the capillary. The polarographic sensitivity (i_D/C) is proportional to $m^{2/3}\tau^{1/6}$, or, in terms of the rate of increase of surface area of the drop $\left(\frac{dA}{dt}\right)$, to $\tau^{1/6}\frac{dA}{dt}$. If the rate of flow of mercury is increased sufficiently, the mercury no longer issues from the orifice in discrete drops, but in a fine stream. It has been possible, however, by constructing a capillary tube with orifice larger than the bore higher in the tube, to use an increased rate of flow of mercury without simultaneously increasing the drop-time.

The theoretical equation for the sensitivity of a dropping mercury electrode, as given first by Ilkovič[2], is

$$\frac{i_D}{c} = knD^{1/2}m^{2/3}\tau^{1/6} \quad . \quad . \quad . \quad (1)$$

where i_D is average diffusion current during life of drop; n is number of electrons per mole involved in reduction; D is diffusion coefficient of reducible substance; c is concentration of reducible substance; m is rate of flow of mercury; τ is drop-time.

Kolthoff and Kahan[3] have shown that, in decinormal potassium chloride solution, the mercury drop just before it falls is suspended from a narrow neck of mercury, and is not attached to the glass of the capillary. In considering the relation between drop-time and dimensions of the capillary, therefore, we may use Tate's equation $Mg = 2\pi r_0 T$, or the modification adapted by Hawkins and Brown[4]:

$$m\tau g\,\frac{(\rho_{Hg} - \rho_s)}{\rho_{Hg}} = \varphi r_0 T \quad . \quad . \quad (2)$$

where r_0 is radius of capillary at orifice; T is interfacial tension; ρ_{Hg}, ρ_s are densities of mercury and solution respectively; φ is a function of $r_0/V^{1/3}$ which varies with the ratio of radius of capillary and radius of drop.

Equation (2) has been tested for the dropping mercury electrode, using the experimental data from Maas[5] and from Muller[6], selecting 380 dynes cm.$^{-1}$ for the interfacial tension of mercury in decinormal potassium chloride. It will be seen that, for a given capillary immersed in a given solution at constant temperature, $m\tau$ is approximately constant, and the value of $|\varphi|$ is much closer to 2π than has been reported for other liquids.

Data from Maas[5]
0·1 *N*KCl; 25° C.; $r = 18{\cdot}9\,\mu$

m	τ	$m\tau$	φ
mgm./sec.	sec.		
1·084	4·13	4·48	5·65
1·653	2·69	4·45	5·62
2·221	1·99	4·42	5·58
2·789	1·59	4·45	5·61

Data from Muller[6]
0·1 *N*KNO_3; $r = 27\,\mu$

m	τ	$m\tau$	φ
mgm./sec.	sec.		
2·56	2·64	6·76	5·99
2·19	3·04	6·62	5·87
1·82	3·66	6·66	5·90
1·44	4·63	6·67	5·91
1·06	6·27	6·65	5·90

Although mercury does not wet glass, the rate of flow from the dropping mercury electrode follows Poiseuille's equation[2], provided that the pressure is corrected for the back pressure caused by the surface tension of the expanded drop, and also the hydrostatic pressure when the capillary is immersed in a solution. The kinetic energy of the issuing mercury is very small (~ 0·1 per cent of the potential energy of the corresponding mass of mercury at the height of the reservoir), and may be neglected.

$$\frac{V}{\tau} = \frac{\pi P r_c^4}{8\eta l}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where V is volume of single drop; P is corrected pressure; η is viscosity coefficient of mercury; r_c is radius of capillary; l is length of capillary (if of uniform bore).

From equations (2) and (3) we have

$$\frac{\pi P r_c^4}{8\eta l}\,g\rho'\tau = \varphi r_0 T \quad . \quad . \quad . \quad (4)$$

Substituting in equation (1),

$$\frac{i_D}{c} = k'nD^{1/2}\,\frac{T^{1/6}}{\eta^{1/2}}\,\frac{P^{1/2}r_c^{2}r_0^{1/6}}{l^{1/2}} \quad . \quad . \quad . \quad (5)$$

Thus, in a given solution at any fixed temperature, with n, D, ρ, T, η all constant, τ will be proportional to $\frac{l}{P}\frac{r_0}{r_c^4}$; $\frac{i_D}{c}$ will be proportional to $\frac{P^{1/2}}{l^{1/2}}\,r_c^{1/2}r_0^{1/6}$.

For a uniform capillary, $r_0 = r_c = r$,

τ will be proportional to $1/r^6$
$\frac{i_D}{c}$ will be proportional to $r^{13/3}$ } with P, l constant.

If the drop-time is to have a value between 1 and 6 sec., the radius of a uniform capillary may be varied only by a factor 1·82, the polarographic sensitivity varying at the same time by a factor 3·65.

It is possible to increase the sensitivity of a capillary without changing P and l (where l is now the effective length consistent with the application of Poiseuille's equation), if it is arranged that the radius at the orifice is greater than the radius higher in the tube. The drop-time remains constant if r_0/r_c^4 is kept constant, so that although there is a much faster flow of mercury through the tube the mercury is discharged in large discrete drops. With r_0 greater than r_c and r_0/r_c^4 constant, the sensitivity will be proportional to $r_c^{1/6}r_0^{1/6}$, that is, $r_0^{2/3}$ or $r_c^{1/3}$.

Thus, if the radius of the capillary is doubled, the radius of the orifice must be increased sixteen times to maintain a constant drop-time. The sensitivity (or rate of increase of surface area) will be increased 6·35 times without any variation of P or l.

This special type of capillary may be constructed by fusing together capillaries of the required dimensions, or empirically by cutting off a pulled thermometer capillary just beyond its narrowest part. One such tube had the constants $m = 6{\cdot}5$ mgm./sec., $\tau = 3{\cdot}7$ sec., $m^{2/3}\tau^{1/6} = 4{\cdot}3$ mgm.$^{2/3}$ sec.$^{-1/2}$, and functioned satisfactorily in the polarographic circuit for more than a year. The expected increase in polarographic sensitivity was obtained, but the residual current was so large as to preclude the use of the highest galvanometer sensitivities. This phenomenon must be ascribed to the increased condenser current (i_c) associated with the increased electrical double layer at the drop surface. For a uniform interfacial charge distribution,

$$i_c = K\psi\,\frac{dA}{dt} = K'\psi m^{2/3}\tau^{-1/3},$$

where K is average capacity of double layer per unit area; ψ is potential difference between mercury surface and solution.

The slope of the condenser current curve will be proportional to the rate at which fresh surface is exposed, that is, to $r_0^4/r_c^{1/3}$. If r_0 is doubled with τ held constant, the slope will be increased 6·35 times. Moreover, the stirring of the solution, induced by the rapid formation of large mercury drops, may lead to acceleration of transfer of reducible substances to the mercury surface. Lingane and Loveridge[1] have already reported a deviation from linearity between $\frac{i_D}{c}$ and $m^{2/3}\tau^{1/6}$ for rapidly dropping capillaries.

It is thus probable that the new type of capillary will be useful in special applications rather than in routine polarographic analysis.

This work was done as a member of a team financed by the Agricultural Research Council to work on the diagnosis and cure of mineral deficiencies in plants.

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[1] Lingane and Loveridge, *J. Amer. Chem. Soc.*, **66**, 1425 (1944).
[2] Ilkovič, *Coll. Czech. Chem. Comm.*, **6**, 498 (1934).
[3] Kolthoff and Kahan, *J. Amer. Chem. Soc.*, **64**, 2553 (1942).
[4] Hawkins and Brown, *J. Amer. Chem. Soc.*, **41**, 499 (1919).
[5] Kolthoff and Lingane, "Polarography" (Interscience Publ.).
[6] Muller, *J. Amer. Chem. Soc.*, **66**, 1019 (1944).

RESEARCH ITEMS

Third Gujarat Prehistoric Expedition Finds

PREVIOUS reports on the third Gujarat Prehistoric Expedition, by H. D. Sankalia and I. Karvé, have already been noticed in *Nature*. The latest report is on "The Human Remains Discovered so Far", and is by I. Karvé and G. M. Kurulkar (Research Institute, Deccan College, Poona. *Times of India Press*, 1945). The general sequence as outlined previously has not been modified. Separated by thick sterile deposits from lower palæolithic gravels, there occur levels containing pigmy implements and bone splinters, some of them perhaps shaped. Towards the top of these levels pottery appears and increases in amount, while at the same time the quantity of microliths grows less. The same kind of thing occurs in rock-shelter sites in the Central Provinces. As regards the skeletons found, some little information is vouchsafed, and there are a few not very clear illustrations. Physical anthropologists, however, will probably not be entirely satisfied with the account given. Doubtless a more complete description will be given when the investigations have been concluded.

Light from Glow-worms

IN an article entitled "Contribucion Al Estudio Del Espectro De La Luz De Las Luciernagas" (*Pub. Fac. Ciencias Fisicomat.*, **3**, No. 4, Universidad Nacional De La Plata, December 1944), Rafael Grinfeld describes his experiments and the results obtained by examining the light of glow-worms. Prof. Grinfeld constructed a small spectrograph at the Institute of Physics of La Plata, with which it was found that the spectra of the light emitted extended continuously from the red (7100 A.) to the green-yellow (5120 A.), and the green-blue (4900 A.). The maximum obtained coincided very approximately with the maximum sensitivity of the human eye. A considerable amount of space is devoted to an examination of the theories of luminescence, and special attention is given to the theory advocated by Dubois in 1885, that luminescence is due to the reactions of luciferase and luciferin. In a luminous organ, light is produced by the entry of hæmolymph, or blood containing luciferin, to the area containing luciferase. More recent research has tended to confirm Dubois's theory, and reference is made to Harvey's discovery in 1916 that in the cases of the American glow-worms *Photuris* and *Photinus*, and the Japanese *Luciola* and *Cipridina*, analogous effects to those observed by Dubois are in evidence.

Cell Polarity

E. W. SINNOTT (*Amer. J. Bot.*, **31**, 388; 1944) has examined the cell divisions of the developing fruits of *Cucurbita*. These fruits range in the relationships of lengths and widths. Growth had been shown to be much more rapid in the plane of length as compared with that in the width plane in those fruits which were elongated. The author shows that the similarity of the mitotic figure is correlated with the direction of growth. The orientation of the telophase axis closely approaches that of the actual division, but the anaphase and metaphase axis do this with less exactness. This suggests that the mitotic figure rotates to its final position. This position is determined by the cytoplasm. This cytoplasmic polarity is the first visible expression of the morphogenetic control. A visible result of this cytoplasmic pattern is shown by E. W. Sinnott and B. Bloch (*Proc. Nat. Acad. Sci.*, **30**, 388; 1944) in the regeneration of *Coleus* after partial sovering of the stem. Those pith cells from which xylem strands are formed exhibit lignification in the secondary walls, with peculiar contours which may include several cells at once. There is a relation between groups of cells in the regeneration of a particular structure. The similarity to lines of force, Liesegang rings and colloidal properties is striking.

Gastric Cancer in Mice

BY hybridization followed by inbreeding, L. C. Strong has produced a strain of mice (*NHO*) which developed gastric cancer on injection with methylcholanthrene (*J. Nat. Cancer Inst.*, **5**, 339; 1945). Eight generations of these mice were injected with methylcholanthrene, and they were selected for resistance to tumour formation at the site of injection. Mice of later generations of the strain developed gastric cancer spontaneously. Dr. Strong suggests that the carcinogenic agent has been responsible for bringing about a germinal mutation that causes a susceptibility to the development of gastric cancer. Methylcholanthrene would thus have a twofold effect: (1) converting somatic tissue into gastric carcinoma; and (2) changing the germ plasm so that the character of the gastric mucosa is changed. Injection with methylcholanthrene appeared to raise the mutation-rate; thus four obvious mutations were observed in 1,500 mice injected with the carcinogen, while only eight mutations have been seen in 210,000 normal mice. In discussing the paper, D. F. Jones and H. B. Andervont suggest that the result might have been due to selection. Apart from the genetical problems involved, the animals developing gastric cancer should be of value in cancer research.

Rust-resistant Clover

LATE-FLOWERING varieties of subterranean clover in Australia are frequently attacked by the rust-fungus *Uromyces trifolii*, but early maturing types are not susceptible. K. Loftus Hills has shown (*J. Counc. Sci. and Ind. Res.*, Canberra, **17**, (2), 74; 1944) that resistance to the disease is an inherited character. The late variety, Mt. Barker, was crossed with the early kind, Mulwala, and, in the third generation, both early and late immune segregates were obtained. These also possess, to a large extent, the agricultural value of the parents.

Seedless Fruits

THE role of growth-regulating substances in the production of seedless fruits has been included in the general review of the action of these substances by J. van Overbeek (*Ann. Rev. Biochem.*, **13**, 631; 1944), where the work of Gustafson in particular is summarized. Work upon this specific subject, however, is reviewed by P. Maheshwari (*Sci. and Culture*, **6**, 85; 1940), who includes many references to Japanese work (especially that of Yasuda) not often referred to by the American workers.

Solanum Grafts

L. R. Detjen (*Proc. Amer. Soc. Hort. Sci.*, **43**, 147; 1943) describes an uncompleted experiment of exceptional interest on *Solanum* grafts. 'Earlianna' tomatoes were grafted on to *Datura stramonium* L., *Nicotiana tabacum* L., *Solanum tuberosum* L., *S. nigrum* L. var. *guineense*, and *Lycopersicon esculentum*

Mill. In each case the flowers of the grafted plants were self-pollinated and the resulting seed saved and sown. No seed was available from the '*S. nigrum*' plants, but seed from the other plants showed notable differences in germination rate, and the resulting seedlings showed differences in vigour, those from the '*Datura*' seed being most, and those from the '*Nicotiana* plants' being least, vigorous.

The Drakensberg of Natal

THE great wall of the Drakensberg, forming the western boundary of most of Natal, is a spectacular erosion scarp which is as old as South Africa itself, since its development began when Gondwanaland was dismembered in the late Jurassic. The origin and evolution of this striking feature is described by L. C. King (*Trans. Geol. Soc. S. Africa*, **47**, 255; 1945). Emission of the Stormberg lavas provided a volcanic landscape which became well planed in the Basutoland region at about 5,000 ft. above sea-level. When the outline of South Africa came into existence, this 'Jurassic' land surface, remnants of which can still be recognized, was tilted southwards in Basutoland, and eventual east and west drainages were shed from a divide near the eastern coast. The short eastern drainage soon developed a steep slope or scarp facing seawards. This was the ancestral Drakensberg, with its initial site probably near the axis of the Natal Monocline. From the Cretaceous to the Miocene, both drainages developed widely planed landscapes; but owing to the shorter distance to the sea, the eastern system had the advantage and gradually forced back the asymmetrical divide not only against the original 'Jurassic' surface, but also against the 'High Veld Miocene' surface that was being produced by the western drainage. Thus the Drakensberg of northern Natal separates the two 'Miocene' surfaces of the High Veld and Natal, while the southern and higher part separates the Natal surface from the Basutoland plateau. During the Miocene, South Africa was uplifted and the chief cycle of erosion terminated in the coastal region. But in the upper reaches of the river systems it has continued up to the present day, steadily forcing the Drakensberg to the west, while later cycles have been progressing up the rivers. No younger cycle has yet reached the escarpment and will not do so, according to King's estimates, for about ten million years. The Drakensberg has already receded more than 100 miles at an average rate of about 1 ft. in 230 years.

High Rupturing Capacity Fuses on Medium-Voltage Circuits

A PAPER read by R. T. Lythall in London last year before the Institution of Electrical Engineers reviews the problems of excess and fault current protection in so far as they may be solved by the use of high rupturing capacity fuses, or by developments based upon these fuses. A brief commentary on non-tripping and tripping types of fuses and on the fault-clearance ability of the cartridge fuse is followed by consideration of the various forms of protection afforded. A survey is made of future possibilities, with special reference to a scheme for open-circuit protection, a new time-limit fuse with an accuracy equal to that of the high rupturing capacity cartridge fuse and which may supersede the overload coil with a shunt fuse, and a solution of the earth-fault protective problem. The paper also considers the selection of fuses for different duties, the economics of fused switchgear, and the need for fuse designers to attempt a greater measure of standardization.

Magneto-Hydrodynamic Waves and Sunspots

WITHIN the last two years, Hannes Alfvén has dealt with a new theory of sunspots, and has provided a summary of the results of his investigations (*Mon. Not. Roy. Astro. Soc.*, **105**, 1; 1945). In approaching the sunspot problem he postulates the existence of the magnetic field which is always associated with sunspots, and assumes that this field is the primary phenomenon. If there is a magnetic field over a certain region of an electrically conducting atmosphere, the hydrostatic pressure within this region is decreased by the magnetostatic pressure, and this decrease in pressure explains the cooling of the spot. For hydrostatic equilibrium in the solar atmosphere the density of matter at a certain level must be always the same, and as a consequence a static equilibrium is possible only if the temperature in the magnetic field is lower than that outside it. As a spot magnetic field cannot be produced near the surface of the sun, it is supposed to originate near the centre of the sun, from which it is transmitted outwards along the magnetic lines of force of the sun's general magnetic field. This transmission is effected by a new type of wave, the "magneto-hydrodynamic wave', with a velocity of the order of one metre per second, so that it reaches the solar surface in about forty years, producing strong magnetic fields there. The wave front intersects the solar surface at high northern and southern latitudes, proceeding later towards the equator, and this affords an explanation of the wandering of the spot zone from high to low latitudes. Comparison of a 'sunspot zone progression curve' with theory enables certain conclusions regarding the sun's general magnetic field to be drawn. It appears that the sun's dipole moment is between $1{\cdot}5 \times 10^{32}$ and $6{\cdot}2 \times 10^{33}$ gauss cm.^{3}, and that the boundary between the dipole field and the homogeneous field lies within $2{\cdot}4 \times 10^{10}$ cm. from the centre. This second result implies that the currents responsible for the solar magnetic field are essentially situated inside one third of the solar radius—a view which is not unreasonable from other considerations.

Determining Position During Flight

IN a paper entitled "Method of obtaining an Astro-fix employing only Sextant, Chart and Short Tables of Predetermined Calculations" (*Mon. Not. Roy. Astro. Soc.*, **105**, 1; 1945), J. H. Clarke shows how to obtain position lines at right angles and parallel to great circle routes. Before the flight, it is necessary to calculate the altitude of a selected star as observed from the place of departure at the instant of its crossing the great circle route. During the flight another observation of the star's altitude is made at a time as near as possible to the predetermined G.M.T. of its transit, and the difference between these two altitudes gives the distance run along the great circle route, from which a position line is obtained at right angles to the route. To obtain a position line parallel to the route, before the flight a calculation of the altitude of a suitable star is made when its azimuth is 90° different from the direction given by the great circle. During the flight the altitude of the star is taken when it is as near as possible to this second predetermined time. The difference in altitudes enables a position line to be drawn. If any of the observations are taken a minute or two before or after the proper G.M.T., corrections can be applied by means of a precomputed table. The method has the great advantage in necessitating only the minimum amount of calculation during the flight.

BREEDING METHODS IN LIVESTOCK IMPROVEMENT

PROBABLY at no time during the past hundred years has there been so much current of changed attitudes and values sweeping through the minds of stockbreeders. While the general public may have noted the effects of the war-time food policies on milk production and on the sheep, pig and poultry populations, it is fair to suggest that only those who face the practical aspects of the British livestock industry recognize the multiplicity of problems that the war situation, added to the general trends, has left. The recent years have thrust many changes upon this branch of British agriculture—not the least of which may be those of thought regarding the aims, methods and responsibilities of the different sections of the industry. It may be significant, in one sense, that, throughout the whole of the meetings on February 26 and 27 of the British Society of Animal Production, the well-known and still hardy phrase 'the stud farm of the world' was not once used. There was no lack of opportunity, since breeding methods, techniques and aims were the main items under discussion.

The situation in poultry breeding adumbrates also some of the major problems of improvement in the larger farm animals. As Mr. Michael Pease defined it, the empirical methods of the past have more or less rapidly raised production to a level or ceiling beyond which progress is slow or impossible—the practical problem now is not grading up but seeking enhanced production within 'improved' stocks. His work at Cambridge and Reaseheath represents one approach to the problem in poultry, that of Dr. A. W. Greenwood at Edinburgh another, and complementary, attack. The former utilizes inbreeding to develop lines, which may or may not be of the same productivity as the control stocks, but which may be combined to give more productive outbred lines within the pure breed. This procedure, deliberately pursued, is new to practical stockbreeding in Great Britain; and the investigations now in hand, involving 'top crossing' inbred lines, are designed to discover the part that cross-breeding can play in improving performance and whether it can produce as good stock as does out-breeding. Within the White Leghorn breed and under the specific conditions of these experiments, there has been no significant increase of egg production so far, but the results are sufficiently encouraging to warrant continuance of the work.

The Edinburgh investigations also use the inbreeding technique, but in different degrees, and to the different end of studying the physiological components of egg production. A series of selected inbred lines of Brown Leghorns has been established under as uniform as possible conditions of feeding and management, each line being distinguished by one particular attribute, such as intensity of laying, persistency, small egg size, large eggs, body size, etc. Concentration on a single productive characteristic in one line has enabled not only the genetic basis of that character to be studied but also the significance of other important conditions, such as mortality, livability, and resistance or susceptibility to tumours, to be recognized and analysed in relation to the practical requirements of high production, vigour and stamina.

The larger farm animals cannot usually be kept in numbers under uniform conditions, so that differential responses to environment are important in practice. 'Suitability to environment' has been given lip-service as a breeding aim, yet the recession of the breeding centres, which follows, perhaps inevitably, the phase of widening influence and distribution of improved types, emphasizes the significance of adaptability of type to environment. Moreover, the ways in which a breed population is built up, in relatively small units, with possibly different breeding systems and standards in these units, point to the necessity that breeding policies should relate to the breed as a whole. The ultimate problem is that of the frequency of desirable, or undesirable, genes within the breed; it is one of population genetics.

However, as Dr. J. E. Nichols was careful to point out in introducing the topic, economic, or performance, characters are greatly influenced by feeding and management; their heritability is relatively low. Therefore the general question is one of discriminating between how much progress is attributable to genetic improvement, and how much is due to environment. The first, and probably the easiest, steps upwards from low average performance-levels can no doubt often be made by improved husbandry, but the real genetic gains can only be achieved by appropriate selection and breeding methods. The discussion revealed doubts as to whether in the British dairy cattle breeding industry, for example, the necessary performance data have yet been acquired, or those available used enough, to enable modern selection procedures to be widely applied. Future progress will depend upon suitable arrangements for the collection, analysis and interpretation of adequate data to provide standards of selective registration upon which the breeders can base their breeding policies.

A particular tool which may be used is artificial insemination, and a series of papers gave opportunity for a searching review of its practical application and problems.

Following an account of developments in Denmark, Canada and the United States, Mr. Twinch stated the essential requirements for comparing progress with artificial insemination—uniformity and simplicity in the systems of recording the relevant data, and agreement on methods of assessing the final results. Mr. D. L. Stewart described the organisation and administration of a centre, based upon experience at Reading, and directed attention to the need for all heifer offspring to be marked and afterwards recorded if the full benefits of the technique were to be estimated. Mr. L. S. Rowson proved that proper care and management of bulls at centres involved more than control of nutrition and husbandry; inferior performance in service and failure of sex drive are largely attributable to mishandling of the animals owing to lack of knowledge of the psychological processes involved in the sexual act. The scope for observations on behaviour in this respect is immense; and such studies at the Cambridge centre show that the field for research is widened far beyond that of the physiology and biochemistry of reproduction. On the latter, Dr. Arthur Walton contributed an excellent historical summary together with a critical account of recent investigations, including those of the various fractions of egg-yolk medium in relation to their effects in sperm dilution and storage.

Dr. Walton's lesson that organisation must not be allowed to outrun knowledge, and that provision for fundamental research is essential, was fully supported

by considerations raised by speakers concerned with the actual technique in its practical application. Thus, even with the necessary density of cow population within reasonable distance, the successful operation of an insemination centre depends upon a satisfactory recognition of the administrative, economic, and technical problems, in themselves and in their inter-relations. For example, if artificial insemination is to be used as a means for milch cattle improvement, a centre must clearly be able to supply semen from proved superior bulls. How can these sires be chosen with sufficient certainty? Are such bulls available in sufficient numbers and at a reasonable cost? The cost of inseminations must be made competitive with that of natural services; the results in terms of service efficiency, or conception-rates, must be comparable with natural matings, and those in terms of the performance of progeny must be demonstrably advantageous, so that farmers are encouraged to use the centres. Further, the centres must have definite long-term breeding policies.

A full report of the proceedings will be published.

J. E. Nichols.

NATIONAL ACADEMY OF PEIPING AND ITS WAR-TIME ACTIVITIES

THE National Academy of Peiping was founded by the National Government of China on September 9, 1929, with Dr. Li Yu-Ying as president and Dr. Li Shu-Hua as vice-president. It consisted originally of nine separate departments, the Institutes of Physics, Radium, Chemistry, Materia Medica, Physiology, Zoology, Botany, Geology, and Historical Studies and Archæology. The new Academy flourished and in a few years had made valuable contributions to many different fields of research. By 1935–36, however, the political situation in the northern provinces of China made necessary the evacuation of several institutes to safer areas. On the outbreak of war in 1937, Peiping was immediately taken over by the Japanese, and the Academy was forced to abandon all its remaining activities there. Despite the confusion, some books and equipment were moved southward and eventually, despite immense practical difficulties, the Academy was able to resume much of its work at Kunming. During the War, the policy of the Academy has been to devote its attention largely, but not exclusively, to the immediate needs of the nation.

In the Institute of Physics research work was originally devoted largely to problems in photography, spectroscopy, piezo-electricity, and geophysics. After the evacuation to Kunming, attention was turned mainly to practical problems, particularly the manufacture of optical instruments. A great variety of optical parts are now produced; 500 microscopes have been built as well as 150 sets of optical parts for surveying instruments. The optical division also repaired apparatus for the American Air Force in Kunming. The Institute prepared 1,000 piezo-electric quartz plates for stabilizing transmission from numerous low-power radio stations established throughout Free China. The Institute's geophysical surveys led to discoveries of great economic importance.

In Peiping the Institute of Radium consisted of three laboratories for studying chemistry, radioactivity, and X-rays. The radioactivity of protoactinium was closely investigated, as well as the radioactive and chemical properties of many Chinese minerals. On the outbreak of war, this Institute moved to Shanghai, where work was carried out on the absorption coefficients of β-rays, certain colour effects of β- and γ-rays on glass, and the analysis of alloys by X-ray methods. When conditions in Shanghai became impossible, Dr. Choong, who had been engaged in spectroscopic investigations, made his way to Kunming and resumed work there, primarily on the fine structure of quartz. The Shanghai laboratories continued to work, under Dr. Lu, but were isolated for more than three years.

Since its evacuation to Kunming, the Institute of Chemistry has largely concerned itself with practical problems such as the extraction of dyes from local plants, the preparation of medicines and the manufacture of industrial alcohol. Time has also been found for some purely academic research, including synthesis of substances related to vitamin K and to rotenone, investigations of pinacol rearrangements, and the study of Grignard compounds and cobaltammine complexes.

Extensive research on Chinese drugs was done before the War at the Institute of Materia Medica, but this was twice interrupted by evacuation, first to Shanghai and later, in part, to Kunming. Dr. Chuang has made notable contributions to the chemistry of hormones, and, despite great difficulties, has continued this work since his arrival in Kunming in 1944. Intensive search has been made for new synthetic antimalarials. Drugs such as ephedrine and vitamin B_1 have been prepared on a commercial scale.

Before evacuating to Kunming, the Institute of Physiology carried out investigations in experimental biology, cytology, and physiology. At Kunming some applied research was started, but lack of staff compelled the abandonment of all research in 1943.

The main work of the Institute of Zoology has been ecological studies throughout China. After evacuation to Kunming a detailed study was made of the freshwater fauna, reptiles, and spiders of Yunnan.

The Institute of Botany has worked mainly on the taxonomy of Chinese plants. Since the evacuation to Shensi Province, the work has continued with the plants of north-west China, particular attention being given to plants of economic importance; extensive collecting expeditions have been organised.

While in Peiping, the Institute of Geology co-operated with the Geological Survey of China and made many important contributions to knowledge of China's geological history. One of its best-known discoveries was that of the remains of *Sinanthropus pekinensis* (Peking man). Much time was given to palæontological research. In 1935 the greater part of this Institute moved to Nanking. In 1937 a further move was made to Beipei, near Chungking, where, despite these setbacks, extensive field and laboratory studies, particularly of mineral deposits, have been vigorously pursued.

The Institute of Historical Studies and Archæology was formally founded in 1937 from an existing Committee of Historical Studies. Before the War much work of exploration and discovery was carried out in all parts of China, but particularly round Peiping, with fruitful results. Since its evacuation to Kunming, study has largely been confined to ancient Chinese history, the classification of material from excavations in Shensi, and the collection of material relating to aboriginals of regions bordering China.

RECENT WORK OF THE PHYSICO-MATHEMATICAL INSTITUTES OF THE ACADEMY OF SCIENCES OF THE U.S.S.R.*

Institute for Physical Problems (P. L. Kapitza).

OF all the Academy's institutes this one has had by far the most normal conditions of work during the year under review. After return to Moscow from evacuation in Kazan, all the necessary conditions for scientific work have been fully re-established. The two main lines of work have both been in the field of low-temperature physics: namely, study of physical phenomena close to the absolute zero; and work on the liquefaction of air and production of oxygen.

V. P. Peshkov[1] has shown experimentally the existence of a second form of undamped periodic waves ('second sound') in liquid helium, predicted theoretically by Landau[2]. In contrast to ordinary sound, the density and pressure variations of this second form are slight, and basically the effect is a wave-like transmission of heat. The speed of the waves between 1·3° K. and 2° K. is about 20 metres/sec., which is close to the theoretically predicted value.

A. I. Shalnikov[3] has continued his work on the structure of the intermediate state in superconductors, and has shown that, in agreement with Landau's theory, a tin sphere in the intermediate state splits up into normal and superconducting phases. This was revealed by a bismuth probe as inhomogeneity of magnetic field in a small gap in the sphere. For a sphere 28·4 mm. in diameter the sizes of the regions into which the sphere was split were about 0·4–0·6 mm.

L. D. Landau, on the basis of his ideas about the nature of superconductivity, has obtained a relation between the penetration depth of a magnetic field into a superconductor and the transition temperature.

E. Lifshitz[4] has shown theoretically that the domains of spontaneous magnetization in small iron crystals are plane layers, and he has estimated the dimensions of these layers.

On the technical side, the oxygen turbine liquefier developed by Kapitza[5] has been further studied and improved. A large-scale oxygen factory has been set up, working on the turbine principle.

Lebedev Physical Institute (S. I. Vavilov).

Owing to the work involved in removing the factory which was housed in the premises while the Institute was evacuated, conditions have been far from normal; in spite of these difficulties, valuable scientific results have been obtained.

V. I. Veksler led a cosmic-ray expedition to the Pamirs (altitude 3,860 m.)[6]. A quantitative estimate was obtained of the number of slow strongly ionizing particles, believed to be a product of hitherto unstudied nuclear reactions initiated by cosmic rays. Slow secondary mesons have been found among these strongly ionizing particles, as well as protons. Using a new method of observation, the size distribution of ionization bursts caused by Auger showers was determined for the first time at great heights. As well as the usual Auger showers of electrons, 'penetrating' showers, possibly of mesons, were also found, but their nature is not yet clear.

V. I. Veksler[7] has suggested new principles for the resonance acceleration of relativistic particles.

B. M. Wul[8] has investigated the relation between structure and dielectric properties, and has found a group of substances of very high dielectric constant —more than 1,000 in the case of barium titanate. In parallel with the laboratory investigations, work has continued on the improvement of production methods for high-frequency ceramic capacitors developed in the Institute.

N. D. Papaleksi has directed work on the propagation of radio waves in the ionosphere[9]. P. A. Ryazin has studied propagation in a flat layer between semi-conducting media. V. L. Ginsburg[10] has solved various special problems on the refractive index of an ionized gas, the effect of collisions on conductivity and absorption of radio waves in the ionosphere, the reflexion of impulses from the ionosphere, and other topics.

S. L. Mandelstamm has directed the development of apparatus for the surface analysis of pieces of alloyed steel, and this technique has been successfully applied in industry.

N. N. Andreyev has directed a number of investigations on the propagation of sound in water. He has studied the passage of sound across a boundary at which there is a discontinuity in the sound velocity gradient. L. M. Brekhovskikh[11] has studied the propagation of sound from a point source in a uniform layer of water, taking account of absorption at the bottom, and has also studied the effect of the surface on the power of a point source. Other problems include the influence of bubbles on sound propagation in water[12], measurement of the sound field in the sea, and investigation of sound absorption in various kinds of sediments.

D. I. Blokhintsev[13] has written a monograph on the acoustics of a heterogeneous medium in motion.

S. M. Rytov and A. M. Prokhorov have worked on the frequency stabilization of a valve generator of non-linear oscillations.

S. I. Vavilov has completed an annotated translation from the Latin of Newton's "Opticks", and has also directed work on the production of substances of high luminescent intensity and long duration of luminescence.

Physico-technical Institute (A. F. Joffé).

Owing to delay in its return from Kazan to Leningrad, this Institute has suffered the worst conditions of all, but in spite of this, much interesting work has been done.

A method of measuring conductivity of semiconductors without the use of electrodes has been developed, based on the action of a rotating magnetic field on the induced currents in a suspended specimen. The temperature variation of conductivity has been followed up to temperatures 150° C. above the melting points of the semiconductors.

A study of conditions at the boundary of two semiconductors, applied to photo-cells, has led to the possibility of obtaining selenium photo-cells with an E.M.F. of 1 volt as against the usual 0·3 volt.

The use of semiconductors as stress meters in virtue of the change of conductivity with deformation has shown that, apart from intrinsic changes of conductivity in the material, large effects are produced by the opening and closing of cracks under stress.

P. I. Lukirski[14] has studied the change of rock-salt spheres into polyhedra, when held in vacuum at temperatures just below the melting point.

* Translated and abridged by Dr. D. Shoenberg from an article by A. F. Joffé (*Bull. Acad. Sci. de l'URSS.*, **9**, 259 (1945)).

A. P. Alexandrov has studied the breakdown of polymers under prolonged loading, and has shown that the formation of cracks is not connected with original non-homogeneity of the material as assumed in Griffiths's theory. He has developed a new fluctuation theory of plastic deformation and strength based on the experimental results. In the mechanism of solidification of polymers, it has been shown that an important part is played by certain groups of active macro-molecules, and the idea has been developed that solidification is caused by the formation of a net-like molecular structure. Practical applications of the polymer work include improvements in the quality of lubricating oils, and assistance to industry in producing and using the new high-frequency insulator 'Eskapon', which was developed in the Institute.

P. P. Kobeko has directed work on the properties of ice sheets which has resolved a number of important problems connected with transport over ice. The effects of static and dynamic loads were investigated, and it was found that the deformation of the ice had sharp maxima for certain critical values of the speed.

M. V. Glinkina has collaborated with the medical service in making and studying a special preparation for treating gas gangrene.

Institute of Crystallography (A. V. Shubnikov).

On the theoretical side, A. V. Shubnikov has developed new ideas about symmetry, based on conceptions such as polar and neutral figures, and the opposite equality of figures. N. V. Belov has derived mathematical formulæ for all possible packings of spheres in a crystal, and in particular he has obtained a simplified derivation of the 230 space groups. A new theory of closest packing of anions in crystals has thrown light on a variety of phenomena important in mineralogy and metallurgy, such as cohesion, cleavage, twinning and the sequence of crystallization of the principal types of minerals.

G. G. Lammlein[16] has studied the laws of habit formation in the progressive growth of crystals, and the formation of so-called growth-textures. He has also worked on the connexion between the colours of quartz and the presence of radioactive elements, and has investigated the role of iron ions absorbed in the quartz lattice.

M. V. Classen-Nekludova has continued theoretical and experimental work on light high-tensile materials, in particular a 'glass veneer' of tensile strength higher than that of duralumin, developed by V. K. Burov of the Academy of Architecture.

Steklov Mathematical Institute (I. M. Vinogradov).

I. M. Vinogradov has completed a monograph on analytical methods in the theory of numbers, and their application to the problem of the distribution of fractional parts of the values of functions, and other problems in the theory of numbers.

U. V. Linnik[16] has developed the theory of α-series and obtained results bearing on the distribution of prime numbers in an arithmetical progression.

A. G. Maltsev has obtained new results in the field of Lie's algebra. A. S. Alexandrov has completed a study of the metrization of normal spaces. L. A. Lyusternik has completed a memoir on topological methods in variational calculus. I. G. Petrovski has solved the problem of the propagation of surface waves on a curve in the free boundary of an elastic body. M. V. Keldysh has investigated the approximation to a holomorphic function by an integral function, and the representation of a function of a complex variable in closed regions in terms of polynomial series. He has also obtained new results in the theory of *A*-sets.

Institute of Theoretical Geophysics (O. J. Schmidt).

O. J. Schmidt[17] has developed a new meteoritic theory of the formation of the earth and other planets, based on astronomical data on galactic rotation and on the presence of dark dust-like matter in interstellar space. I. A. Khvostikov and E. S. Kuznetsov have worked on the scattering of light and visibility in the atmosphere.

A. G. Kalashnikov has worked out a theory of the fluxmeter and a new method of studying magnetic properties of minerals. S. S. Kovner[18] has developed a new thermal method of prospecting for minerals, and this has been successfully applied on an experimental scale in Bashkiria. V. V. Beloussov and Ronov have studied problems of geotectonic motions in the earth's core in connexion with the history of the earth.

G. A. Gamburtsev has been in charge of a seismic oil-prospecting expedition to the Apsheron peninsula (Baku area), partly with the aim of giving practical help to oil-prospecting organisations, and also to carry out experiments on the seismic method. A number of peculiarities of the propagation of seismic waves in non-homogeneous media were studied, and the fundamentals of the prospecting technique as applied to the conditions of the Apsheron peninsula were worked out. The work of the expedition is continuing.

Seismological Institute (V. F. Bonchkovski).

N. A. Linden has completed a study of the propagation and reproducibility of deep-focus earthquakes recorded between 1911 and 1944. E. A. Rozova has completed her work, which has been going on for many years, on the focal depths of earthquakes in Central Asia; this provides extensive data for discussion of the structure of the earth's core. V. F. Bonchkovski has investigated the cause of microseismic movements of the first kind, and has shown that they are due principally to the strong westerly winds in Norway.

D. I. Sherman, M. A. Neymark and V. G. Gogoladze have carried out a number of mathematical investigations on topics such as the oscillations of a semi-infinite space with a superposed layer bounded by a plane, and refraction and reflexion of seismic waves. N. V. Veshnyakov and D. P. Kirnos have developed apparatus for observations in epicentral regions.

Regular observations have been made by the Government network of seismic stations, and more than 2,600 earthquakes have been recorded, 16 with focal depths of several hundred kilometres.

Marine Hydrophysical Laboratory (V. V. Shuleikin).

Two main problems have been studied: storms and the relation between oceans and continents. S. V. Dobroklonski has studied the propagation of sound waves in the sea, and has worked out plans for a new type of acoustic analyser. A. G. Kolesnikov has studied problems of ice formation. M. K. Tikhonov has directed work on the corrosion of ferro-concrete structures under sea conditions. A. A. Ivanov, S. P. Levchenko and R. N. Ivanov have developed various new instruments, such as recorders for studying diffraction, refraction, reflexion and absorption of waves, wave generators, meters for

recording speed and direction of sea currents, and so on.

Chief Astronomical Observatory, Pulkovo (G. N. Neuimin).

Work has suffered considerably from the dispersion of the scientific personnel to various places: Tashkent, Leningrad, Alma-Ata, Abastuman and Kitab. Detailed plans have been worked out for the reconstruction of the Pulkovo Observatory and its subsidiaries at Nikolaev and Simeis. With the view of encouraging development in astrophysics, the Simeis Observatory is being reorganised as an independent Crimean Astrophysical Observatory.

G. A. Shajn[19] has completed an investigation of the systematic movements in the rarefied atmospheres of the white super-giants of the α-Cygni type. A peculiar stratification in the distribution of elements was shown to occur, and the particle velocities in the various layers were found to be variable.

G. A. Tikhov[20] has developed a method of measuring stellar temperatures without the use of terrestrial comparison sources, by choosing as a basis of reference the hottest star visible, and treating its temperature as infinite. An important advantage of the method is its independence of the selective absorption of light in the earth's atmosphere.

V. B. Nikonov, using antimony-cæsium photo-cells, has determined the colour equivalents of class *B*8—*B*9 stars, with a precision greater than that of the known American catalogues.

O. N. Melnikov has completed a spectrophotometric investigation of δ Cephei, η Aquilæ and the *K*-effect in Cepheids. The results throw light on the flow of atoms from the outer parts of Cepheid atmospheres.

J.P. = *Journal of Physics* (Acad. Sciences U.S.S.R.)
C.R. = *Comptes Rendus de l'Acad. des Sci. U.R.S.S.*

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[8] Wul, see *Nature*, **156**, 480 (1945).
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[17] Schmidt, *C.R.*, **45**, 229 (1944); **46**, 355 (1945). See *Nature*, **156**, 185 (1945).
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[20] Tikhov, *C.R.*, **47**, 12 (1945).

THE ENIAC, AN ELECTRONIC CALCULATING MACHINE

THE news has recently been released of a major advance in the development of equipment for extensive numerical calculations, in the successful completion of a large calculating machine based on the use of electronic counting circuits. This machine, known as the ENIAC (Electronic Numerical Integrator and Automatic Calculator) is the invention of Dr. J. W. Mauchly and Mr. J. P. Eckert, of the Moore School of Electrical Engineering of the University of Pennsylvania, Philadelphia, where it was designed and constructed. Its development was sponsored by the Ordnance Department of the U.S. Army, through the interest of Col. P. N. Gillon and Capt. H. H. Goldstine. It was designed primarily for the step-by-step integration of the equations of external ballistics, but it includes a flexible control so that it can be applied to many other kinds of calculations within its capacity.

The machine operates by the counting of electrical pulses produced at the rate of 100,000 per second. These are fed to the counting circuits by electronic switching circuits, according to the operation (addition, multiplication, etc.) to be carried out. These circuits count in scale of 10, to ten-figure accuracy. The units in which addition is carried out provide a 'memory' with a capacity of about twenty numbers, results of previous operations, to which immediate access can be had in the course of further calculations; use of punched cards provides an indefinitely large 'memory capacity' for data, intermediate results, or operating instructions, though with much slower access. Final results are delivered on punched cards.

A multiplication table is built into the machine by the connexions of a set of electronic valves. The machine also has three function tables, on each of which a set of values of any function required in the calculation (for example, the resistance-velocity relation for a projectile) can be set by hand switches so as to be immediately accessible to the machine, which can at any stage read a group of function values and interpolate between them in accordance with an interpolation formula specified by the operating instructions furnished to it. An addition of two numbers held in the machine takes about 0·2 millisecond; the multiplication of two numbers of ten decimal digits takes a few milliseconds.

Control of the programme of the operation of the machine is also through electrical circuits. The sequence of operations is supplied to the machine by the interconnexions made between its different units through plug-and-socket connexions and through hand-set switches, and by coded instructions supplied to a programme control unit; the machine then operates automatically according to the sequence of operations so specified. A certain amount of 'judgment' can be included in these operating instructions, in that the machine can be set to select between two alternative courses of procedure at some particular stage of the work, according to the result of a previous operation.

The machine is built up in the form of a number of units each consisting of one or more vertical panels about 8 ft. high and 2 ft. wide, of which there are altogether forty. Each panel carries, at the back, racks of valves, relays, etc., and, at the front, switches, indicating lamps, plugs, sockets, etc. The different units are interconnected by two sets of lines, one set carrying signals expressing numerical information and the other set for control signals; connexions to and from these sets of lines can be plugged into the various units.

The whole machine comprises about 18,000 electronic valves, 3,000 indicating lamps, and 5,000 switches, and takes about 150 kW. in operation. Its flexibility and speed of operation will make it possible to carry out many numerical calculations, in many fields of investigation, which without its assistance would have been regarded as much too long and laborious to undertake.

D. R. HARTREE.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Tuesday, April 23

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at the Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—"How Chemistry helps the Stock-breeder".

Wednesday, April 24

INSTITUTE OF WELDING (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Major R. J. Fowler and Major L. F. Denaro: "The Evolution of Welded Armoured Fighting Vehicles".

ROYAL STATISTICAL SOCIETY, BIRMINGHAM AND DISTRICT GROUP OF THE INDUSTRIAL APPLICATIONS SECTION (at the University, Edmund Street, Birmingham 3), at 6.30 p.m.—Mr. W. A. Bennett: "Quality Control Economics".*

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—"The Scientific Life: its Motivation, Nature and Rewards" (First Meeting). (Speakers: Dr. D. G. Christopherson, Sir Thomas Merton and Dr. A. C. B. Lovell.)

Thursday, April 25

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 3 p.m.—Dr. J. C. P. Miller: "The Summation of Awkward Series".

INSTITUTION OF ELECTRICAL ENGINEERS (at Kingsway Hall, Kingsway, London, W.C.2), at 6 p.m.—Prof. M. L. Oliphant, F.R.S.: "Nuclear Physics and the Future" (Thirty-seventh Kelvin Lecture).

Friday, April 26

PHYSICAL SOCIETY, OPTICAL GROUP (at the Imperial College of Science, Imperial Institute Road, London, S.W.7), at 3.15 p.m.—Dr. C. R. Burch, F.R.S.: "Schwarzschild-Ritchey-Chretien Reflecting Microscopes"; Messrs. F. T. Bannister, W. J. Bates and C. R. Burch, F.R.S.: "A Lenouvel Interferometer".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Tropical Meteorology" (to be opened by Dr. A. G. Forsdyke).*

INSTITUTION OF ELECTRICAL ENGINEERS (joint meeting of the MEASUREMENTS SECTION with the INTERNAL COMBUSTION ENGINE GROUP of the INSTITUTION OF MECHANICAL ENGINEERS, at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. F. R. F. Ramsay and Mr. W. Nethercot: "Engine Ignition Faults and a New Method of Diagnosis and Location during Running".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6 p.m.—Mr. W. Muckle: "Application of Light Alloys to Superstructure of Ships".

INSTITUTE OF PHYSICS, MANCHESTER AND DISTRICT BRANCH (in the large Physics Theatre, The University, Manchester), at 6.30 p.m.—Annual General Meeting. Mr. A. J. Maddock: "Dielectric Heating".

Wednesday, April 24—Friday, April 26

FARADAY SOCIETY (in the Department of Physics, The University, Woodland Road, Bristol).—Discussion on "Dielectrics". (On April 24 at 2.15 p.m.; on April 25 at 10 a.m. and 2.15 p.m.; on April 26 at 10 a.m.)

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN ELECTRICAL ENGINEERING—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1 (April 27).

RESEARCH ASSISTANTS (2) IN ECONOMICS—The Registrar, The University, Manchester 13 (April 30).

ASSISTANT PHYSICIST IN THE RADIOTHERAPY DEPARTMENT—The House Governor and Secretary, Royal South Hants and Southampton Hospital, Southampton (April 30).

LECTURER IN MATHEMATICS—The Registrar, Queen Mary College, Mile End Road, London, E.1 (May 1).

LECTURER IN PARASITOLOGY, and two ASSISTANT LECTURERS IN CHEMISTRY—The Secretary and Registrar, The University, Bristol (May 3).

GRADUATE LECTURER IN CHEMISTRY, a GRADUATE LECTURER IN ELECTRICAL ENGINEERING, and a TEACHER IN MECHANICAL ENGINEERING able to teach Production Engineering Subjects, at the Norwich City College and Art School—The Director of Education, City Hall, Norwich (May 4).

LECTURER for full-time Senior Courses in STRUCTURAL ENGINEERING at the Brixton School of Building—The Education Officer (T.1), County Hall, London, S.E.1 (May 6).

LECTURER IN PHYSICS—The Principal, Technical College, Kingston-upon-Thames, Surrey (May 6).

ENGINEER—The Clerk to the Upper Medway Internal Drainage Board, 71a Bank Street, Maidstone, Kent (May 6).

READERSHIP IN CHEMISTRY tenable at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 7).

LECTURER (Grade II), with qualifications mainly in Physical Geography, and an ASSISTANT LECTURER (Grade III), IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Liverpool (May 15).

ASSISTANT LECTURER IN BOTANY—The Registrar, The University, Reading (May 15).

ADVISER IN AGRICULTURAL ECONOMICS—The Registrar, The University, Manchester 13 (May 18).

SPEECH THERAPIST—The County Medical Officer of Health, County Health Office, College Hill, Shrewsbury (May 18).

BACTERIOLOGIST—The Secretary, Charing Cross Hospital Medical School, 62 Chandos Place, London, W.C.2 (May 22).

ASSISTANT LECTURER IN PURE MATHEMATICS, an ASSISTANT LECTURER IN APPLIED MATHEMATICS, and a READER IN STATISTICS—The Registrar, The University, Leeds 2 (May 22).

ESTABLISHED POSTS in London for men and women who have specialist knowledge or research experience in one of the following subjects: Geography, Geology, Economic and Statistical Analysis, Industrial or Market Research—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting 'JB' (May 31).

DIRECTOR (Professor) OF THE RESEARCH LABORATORY IN ZOOLOGY, and an ASSISTANT REGISTRAR—The Registrar, University of Madras, Chepauk, Triplicane, India (by airmail, May 31).

CHAIR OF BACTERIOLOGY tenable at St. Thomas's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 31).

METALLURGISTS (2, graduates or equivalent standard) as Technical Secretaries to a group of light alloy committees and a group of ferrous metallurgical committees respectively, a qualified METALLURGIST experienced in the manufacture, processing or fabrication of light alloys, a RESEARCH METALLURGIST (of degree or equivalent standard) to undertake research work on welding problems connected with steel, and JUNIOR METALLURGISTS (of degree or equivalent standard) for work on steel and light alloys—The Director of Research, British Welding Research Association, 29 Park Crescent, London, W.1.

FISH CULTURE EXPERT by the Iraqi Government—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.14573.

TEACHER OF SCIENCE in the Engineering Department of the Burton-upon-Trent Technical Institute—The Secretary and Director of Education, Education Offices, Guild Street, Burton-upon-Trent.

LECTURER IN PHYSIOLOGY in the Department of Pharmacy and Biology—The Principal, Birmingham Central Technical College, Suffolk Street, Birmingham 1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Memoirs of the Cotton Research Station, Trinidad. Series A: Genetics, No. 24 (i) Colchicine-produced Polyploids in *Gossypium* (2) Old World Triploid Hybrids; (ii) A Genetic Survey of the Leaf Shape in New World Cottons—a Problem in Critical Identification of Alleles; (iii) The Modifier Concept—a Developmental Analysis of Leaf-shape 'Modification' in New World Cottons; (iv) Canalization of Gene Action in the *Gossypium* Leaf-shape System and its Bearing on Certain Evolutionary Mechanisms. By S. G. Stephens. Pp. 56. 2*s.* 6*d.*, Series A: Genetics, No. 25: The Sea Island Cottons. By J. B. Hutchinson and H. L. Manning. Pp. 13. 2*s.* 6*d.* (London: Empire Cotton Growing Corporation, 1945.) [1810

Ministry of Agriculture and Fisheries. Bulletin No. 9: Bee-Keeping. By Dr. C. G. Butler. Pp. 27. (London: H.M. Stationery Office, 1945.) 9*d.* net. [1810

Imperial Bureau of Horticulture and Plantation Crops. Technical Communication No. 15: Spring Frost Damage in Orchards and its possible Prevention. Pp. 22. (East Malling: Imperial Bureau of Horticulture and Plantation Crops, 1945.) 1*s.* 6*d.* [1810

Other Countries

Department of Public Instruction, Technical Education Branch: New South Wales. Curator's Annual Report of the Technological Museum for the Year ended 31st December 1944. Pp. 2. (Sydney: Government Printer, 1945.) [69

South African Journal of Science. Vol. 61: Being the Report of the Forty-second Annual Meeting of the South African Association for the Advancement of Science. Johannesburg 1944. Pp. xviii+556. (Johannesburg: South African Association for the Advancement of Science, 1945.) 30*s.* net. [69

Smithsonian Miscellaneous Collections. Vol. 104, No. 13: Correlation of Solar Variation with Washington Weather. By C. G. Abbot. (Publication 3807.) Pp. ii+10. (Washington, D.C.: Smithsonian Institution, 1945.) [69

Bulletin of the American Museum of Natural History. Vol. 83, Art. 7: The Neotropical Genus *Syntermes* (Isoptera: Termitidæ). By Alfred E. Emerson. Pp. 427–472. (New York: American Museum of Natural History, 1945.) [69

Bulletin of the Madras Government Museum. New Series, General Section, Vol. 5, No. 1: Iravas and Culture Change. By Dr. A. Aiyappan. Pp. viii+204+12 plates. (Madras: Government Press, 1944.) 16.10 rupees. [69

Carnegie Institution of Washington: Department of Terrestrial Magnetism. Scientific Results of Cruise VII of the *Carnegie* during 1928–1929 under Command of Capt. J. P. Ault. Oceanography, 1–B: Observations and Results in Physical Oceanography; Graphical and Tabular Summaries. By J. A. Fleming, C. C. Ennis, H. U. Sverdrup, S. L. Seaton and W. C. Hendrip. (Publication 545.) Pp. iv+315. (Washington, D.C.: Carnegie Institution, 1945.) 1.50 dollars. [1810

Memoirs of the Numismatic Society of India, No. 1: The Technique of Casting Coins in Ancient India. By Prof. Birbal Sahni. Pp. iii+68+7 plates. (Bombay: Numismatic Society of India, Prince of Wales Museum, 1945.) [1810

South African Institute for Medical Research. Annual Report for the Year 1944. Pp. 48. (Johannesburg: South African Institute for Medical Research, 1945.) [1810

Meddelanden från Oceanografiska Institutet i Göteborg. 7: Iron and Manganese on the Ocean Floor; a Contribution to Submarine Geology. By Hans Pettersson. Pp. 37. (Göteborg: Elanders Boktryckeri A.-B., 1945.) [1810